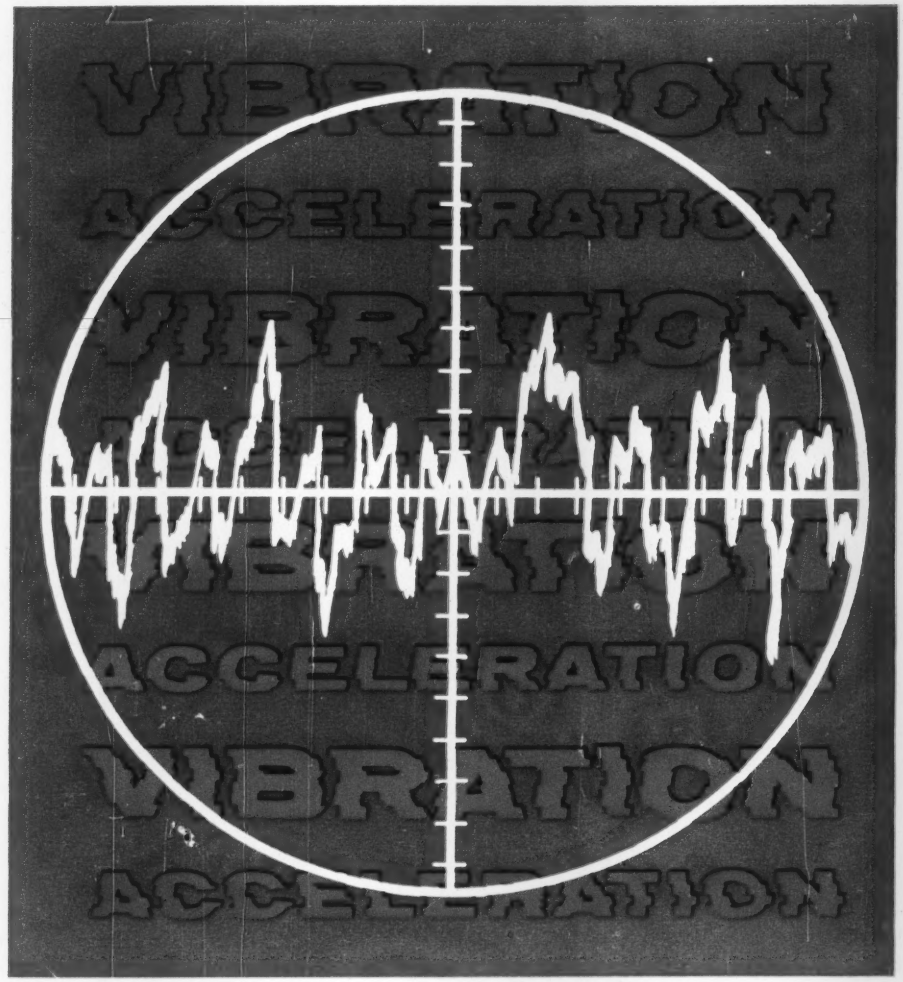
INSTRUMENTS AND CONTROL SYSTEMS

INCLUDING: INSTRUMENT MANUFACTURING • JOURNAL OF THE SCMA • SIMULATION COUNCIL NEWSLETTER



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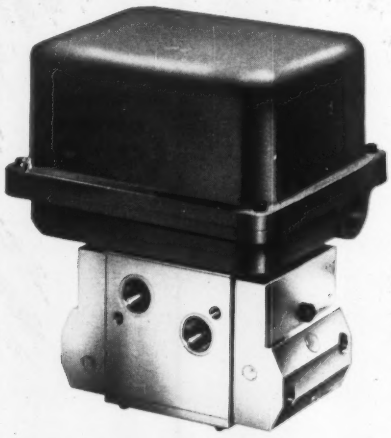

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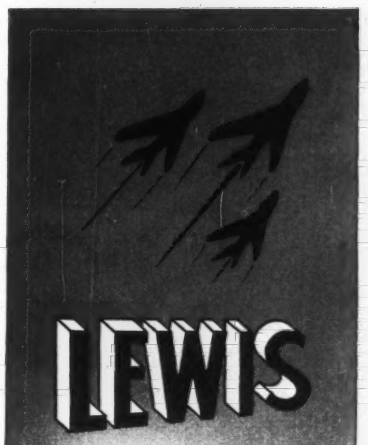

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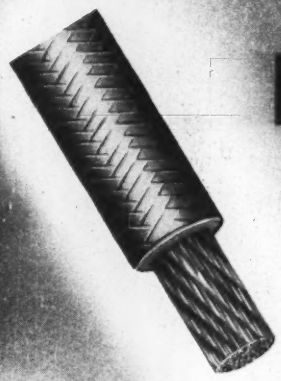

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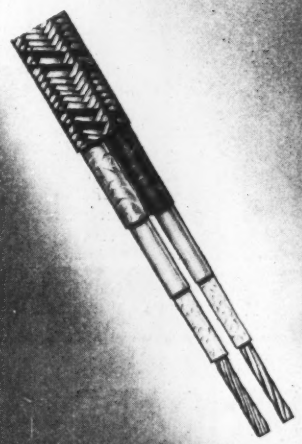

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INSTRUMENTS AND CONTROL SYSTEMS

Formerly INSTRUMENTS and AUTOMATION

APRIL 1959

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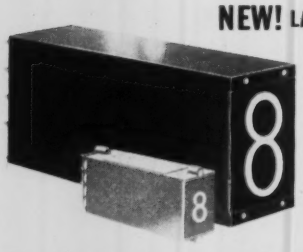

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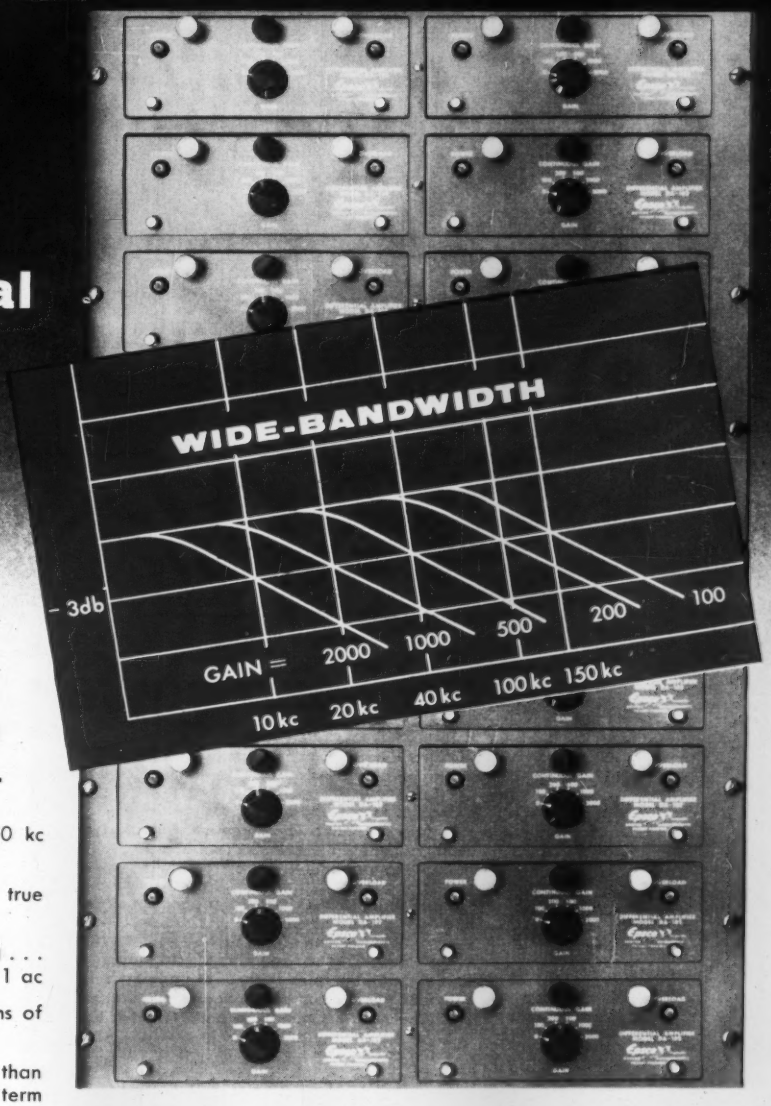
Wide Bandwidth with True Differential Input



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Gaussmeter

provides nine full-scale ranges

MODEL 1295A

RANGES (Gauss)		
0-100	0-1000	0-10,000
0-200	0-2000	0-20,000
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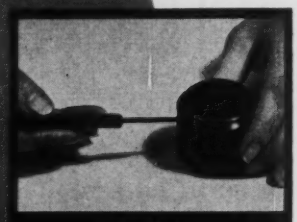
This stable, all transistorized Gaussmeter operates on the Hall Principle and provides a conservative accuracy of ±3% over-all ranges. Accuracy can be increased to ±1% at any point between 500 and 20,000 gausses by use of special probe reference magnets. Response is flat when measuring magnetic fields from DC up to 120 cps. Correction curves are supplied for measurement of fields up to 400 cps.



TYPICAL REFERENCE MAGNET

The Model 1295A Gaussmeter operates from 115-volt, 50-400 cycle power line. Internal switching arrangement and battery holders are also provided for self-contained battery operation. Compartment in back of aluminum case provides storage for probe, reference magnet and power cord. Over-all size is 11 x 7 x 12. Weighs 12 lbs. Net price $420. complete.

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to the editor

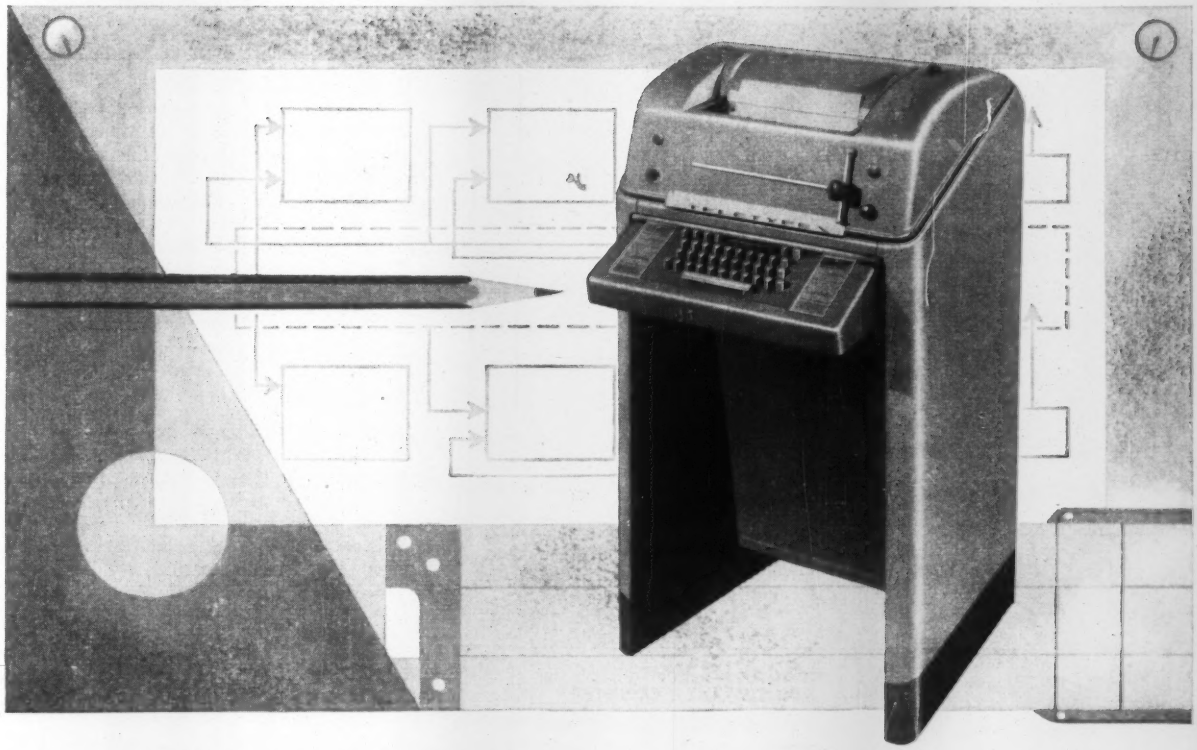
Editors, I&CS:

You won't publish this; nevertheless, my conscience requires me to write you. If you use it, print all of it. Your editorial, A threat to American education and the instrument industry, I&CS 32 (3;Mr'59), 275-8, was as bald a piece of anti-intellectualism as I've seen. Yours is the expression of commerce, whose goddess is Venus, a deified streetwalker (replaced on industrial calendars by Hollwood counterparts) to illustrate the first commercial commandment—sell yourself, more or less. Quite obviously—quite un-Americanly—you are more interested in selling hardware than in education.

Your editorial is a quilt of misstatements, most phrased so deliberately as to be lies. Examples are:

"The university professor is . . . [not] in a completely different status." And his slightly different status today becomes less so, although a shred of prestige and some slight aura of mendicant sacrifice attends him. Nor does he think the high school *teacher* a hack (because many were his own students). Moreover, professors—and precious few of them—object to educationists (a few of whom are educators, too), most of whom are former shop and/or physical education instructors with M. Ed. and D. Ed. degrees. These turned our democratic education into baby-sitting institutions, including much of, and especially landgrant, colleges and universities. Most teachers, high school—universities, are quite aware that instrument salesmen cultivate the teacher less and less, and the educationistical bureaucrats more and more, such as purchasing agents, Deans of Equipment, etc.

An instrument is, after all, a tool, fixed and rigid—let's not become worshippers of it. Most of your readers probably welcome the advent of air traffic, except possibly the hucksters of surface transport. Who among them lament the ice-man's going, or the typewriters' replacing the need of the Spencerian expert? And one more problem: if you can't make hardware reasonably much cheaper, blaming this on union labor (justifiably to a degree—but not huckster bureaucracy?) the Russian, British, Swiss, and other cheaper hardware goes to educate the technologically teeming rise of the rest



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Model 28 Printer. If your system requires a printer for communications or readout, the Model 28 combines traditional Teletype dependability with exceptional flexibility to suit a wide variety of requirements.

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Operates on 5 level Baudot code, with operating speed of 10 characters per second.

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If you'd like detailed information about the Model 28 printer—or our tape punches, readers, and composite set—write to Teletype Corporation, Dept. 23-D, 4100 Fullerton Avenue, Chicago 39, Illinois.

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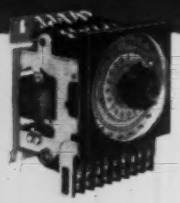
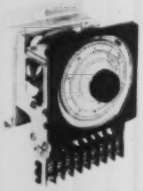
featuring adjustable count automatic reset 10 ampere switches



model HZ4
MICROFLEX RESET COUNTER

Use to control an operation for a preset number of counts. Has spring reset to "0." Dial ranges 19, 400 and 1,000 counts.

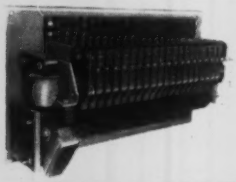
Ask for bulletin 720.



model HZ200
ADD-SUBTRACT COUNTER

Add-Subtract counter — operates from ADD pulses which trip switch at maximum limit — and SUBTRACT pulses which trip switch at "0" limit.

Ask for bulletin 740.



model MT
STEP SWITCH

Use for sequence control from pulses — 19 contacts — 60 cycle coil-break out cam lugs.

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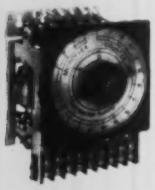

model HZ6
MICROFLEX REVOLUTION COUNTER

Use to control an operation as a function of mechanical movement — drive shaft can be mechanically connected to machine, spindle, conveyor, etc.

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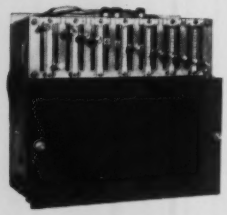

model HM
MULTIFLEX *(Multiple Circuit)* TIMER

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Write us regarding your count problem. Services of Sales Engineers in 25 district offices are available without obligation. Address Dept. IA-459.

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LETTERS—CONTINUED

of the world, accompanied by technicians and ideological literature—*now* compute quickly the expected halflife of American ideals? Perhaps "King" TC Mits has reigned too long, and you-all'd best learn to capitalise [sic] on what little brains any people have? Step 1 of the solution can truly be: do you want education or baby-sitting tool manipulation?

Joe Gorman, Ph.D. (Calif.—Biology)
Saint Louis University
St. Louis, Missouri

There should be no conflict between principle (theory) and practice (hardware); they need each other. We repeat our point: The emotional university prejudice against "hardware" is an obvious and direct threat both to the instrument industry and to technical education in general.

Editor, I&CS:

I have just finished reading your article in the February 1959 issue of *INSTRUMENTS AND CONTROL SYSTEMS* magazine, "Report on Public High School Course in Modern Engineering Physics." This approach, if followed in other communities, could aid in stimulating high school students with a technical aptitude to help fill our country's need for scientific personnel. I am very interested in the possibilities of promoting such a program here in the twin cities of Benton Harbor and St. Joseph, Michigan.

As a member of the Board of Directors for both the Kiwanis Club and the Junior Chamber of Commerce, I hope to work through these clubs as well at the other service clubs and the Board of Education to examine the practicability of such a plan here. We probably do not have the personnel and facilities, of the scope mentioned in the article, but, with the cooperation of the Michigan State Continuing Education Center and the local industries, could start something of this sort.

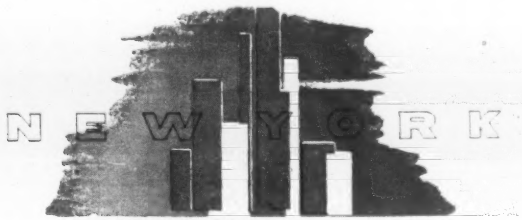
I would appreciate it very much if you could supply me with reprints of this article. I will use these to stimulate interest.

Robert L. Ballard
Whirlpool Corp.
St. Joseph, Mich.

Good luck with your education project and here are your reprints—but read our March editorial carefully and you will see what you might run into.

"the show of the future"

FIFTH INTERNATIONAL automation EXPOSITION



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FIFTH INTERNATIONAL AUTOMATION EXPOSITION

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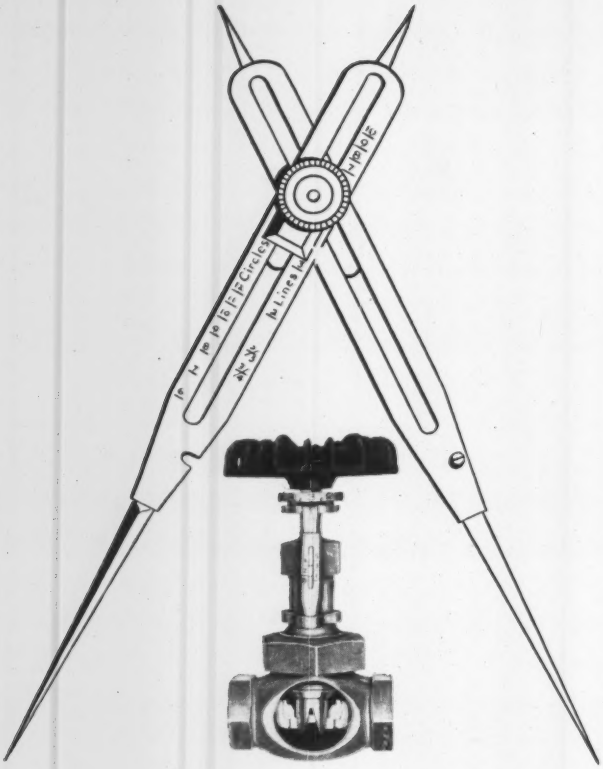


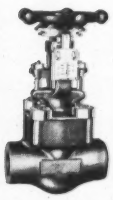
PROPORTIONER

controls flow to save for you

The V-port disc in all Hancock "Flocontrol" Valves insures proportional flow throughout the entire lift of the stem. They are valves that help you achieve uniform product quality through closer control, save steam and fuel on process work, and cut maintenance costs.

"3 in 1" valve design combines variable orifice with shut-off and micrometer dial and pointer. The valve opening can be set within 1/10 turn of the handwheel —you can duplicate all settings easily, instantly. No shut-off valve required—flow is in a straight line, with separate shut-off seating surface located away from the V-ports.

Hancock "Flocontrol" Valves are available in Bronze and Steel to meet the most demanding services. Ask your industrial supply distributor for details.



Hancock "Flocontrol" valves assure positive pinpoint control—eliminate all guesswork.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

HI-58

HANCOCK "FLOCONTROL" VALVES

A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Watertown, Massachusetts

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

For more information circle **10** on inquiry card.

LETTERS—CONTINUED

Editor, I&CS:

From time to time you have published excellent editorials and articles relating to education. Examples would be "Significant Science for Secondary Schools," June, 1958, or "A Proposal for a High School Course in Automation and Industrial Technology," February, 1957.

Would it be possible to obtain reprints of all such articles published within the last five years?

J. J. Maxwell
Head, Instrument Engineering
Sherritt Gordon Mines Limited
Fort Saskatchewan, Alberta

The following editorials on education appeared in INSTRUMENTS and CONTROL SYSTEMS:

1. "Proposal for High School Course in Automation and Industrial Technology," February, 1957
2. "Significant Science for Secondary Schools," M. Kiley, June, 1958
3. "Needed: More State Supervisors of Science and Mathematics," J. Irving, November, 1958
4. "Report on Public High School Course in Modern Engineering Physics," February, 1959
5. "Anti-Hardwarism, A Threat to American Education and the Instrument Industry," March, 1959.

A few reprints of (4) are still available.

Editor, I&CS:

Please send me a re-print of your article "Report on Public High School Course in Modern Engineering Physics" which appeared in the February 1959 issue of *INSTRUMENTS and CONTROL SYSTEMS*, pp. 225-232.

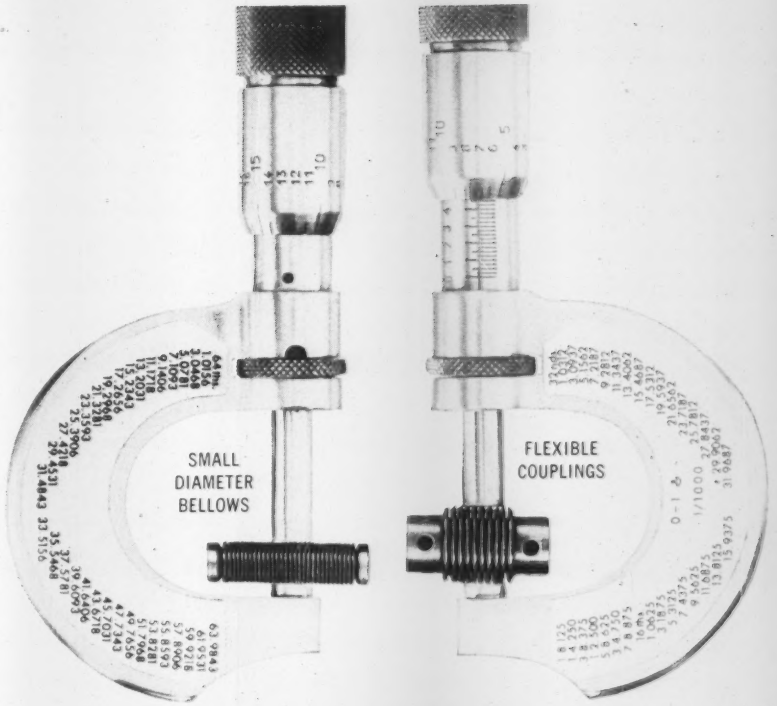
J. B. Jeffries
White Plains, N. Y.

Editor, I&CS:

With reference to the above mentioned notice [*Inq.A-338, Sept. 1958 Ed.*], we ask you kindly to send this prospectus to the Belgian paperwork which is interested in measuring and controlling the moisture content of the paper on the production machine.

N. V. Bakker & Co.
Rotterdam, Holland

The prospectus is from Hans Muller-Barbieri, Wettswil/Zurich, Switzerland, specializing in the sought equipment. The representative of a Swiss company in Holland reads an American magazine to make connections in Belgium . . . We are proud to be a link in such an international chain . . .



MINIATURIZE WITH Robertshaw

Looking for new ways to save space and weight in instruments, aircraft, missiles and other equipment? Investigate these two miniature products by Robertshaw:

Small Diameter Metallic Bellows, only ¼" and 5/16" O.D., provide exceptional strength, precision and sensitivity to temperature and pressure changes. Hydraulically formed without seams to your strictest specifications in a wide range of bellows metals, physical properties and performance characteristics. Available in unlimited quantities.

WRITE FOR BULLETIN F-104.

Small Diameter Flexible Couplings, available from stock, in several metals and sizes as small as 15/32" O.D. . . . smaller diameters custom-engineered on request. Eliminate back-lash, maintain uniform angular velocity, reduce bearing wear and friction in a variety of applications. Stock couplings accommodate shaft sizes ⅛" to ½" diameter.

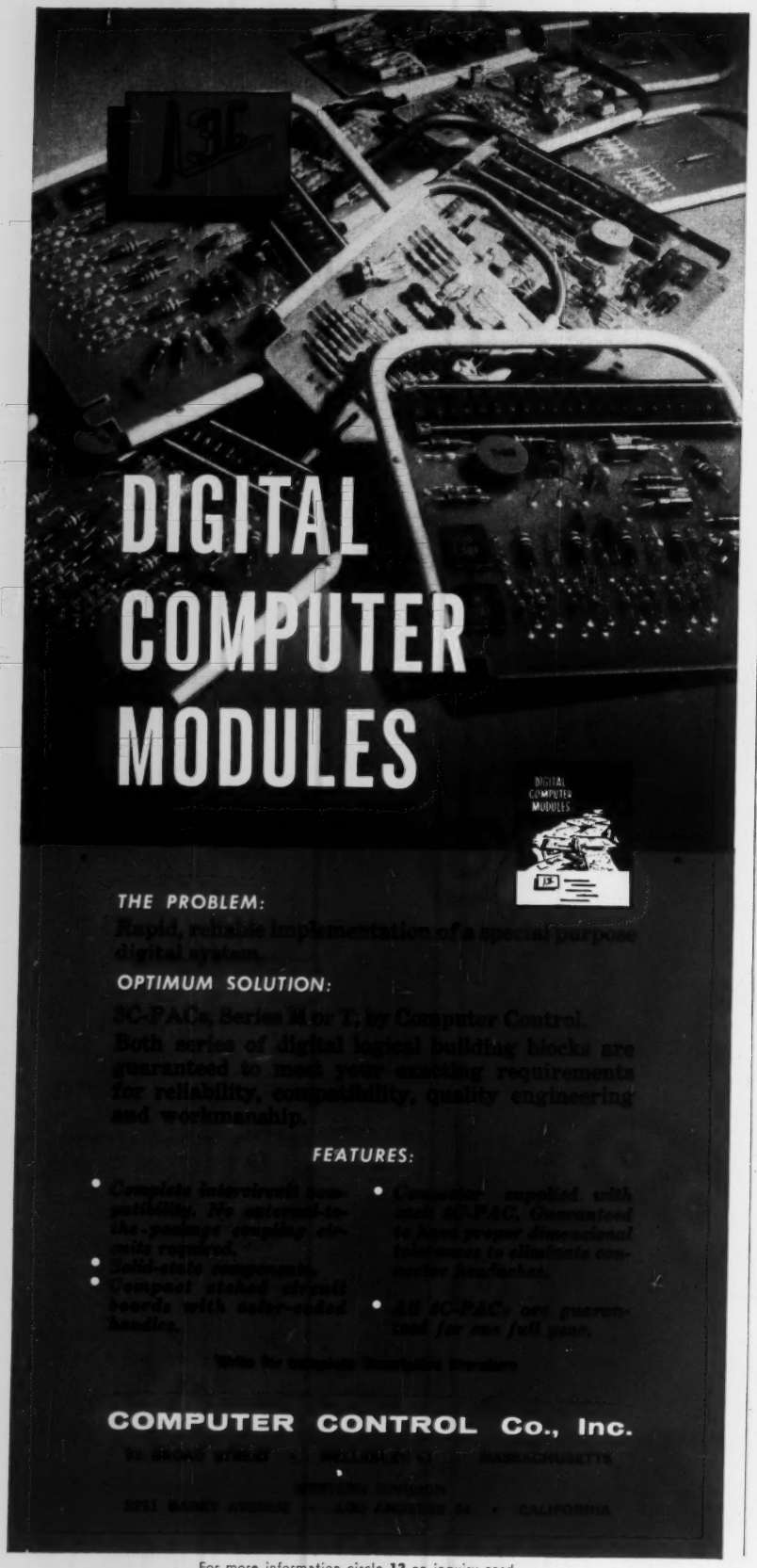
WRITE FOR DATA SHEET F-804.

Mr Controls

Robertshaw-Fulton CONTROLS COMPANY

BRIDGEPORT THERMOSTAT DIVISION • Milford, Conn.

For more information circle **11** on inquiry card.



For more information circle 12 on inquiry card.

LETTERS—CONTINUED

Editor, I&CS:

We are interested in obtaining reprints of the article entitled "Electronic Circuitry" by yourself and Charles F. Kezer.

Henry M. Borella,
Edgerton, Germeshausen & Grier, Inc.
Las Vegas, Nevada

Editor, I&CS:

I have been reading your articles on Electronic Circuitry with great interest and understand that you have published these articles in book form.

Dr. Roger Gilmont
Manostat Corp.
New York 13, New York

The first 100 circuits in our Circuitry series are available in the book "100 Electronic Circuits" by Aronson & Kezer, available from us at $2.00. Vol. 2 (circuits 101-200) soon will be available also.

reader inquiries

Sliding Plate

Professor of biology is seeking plate (approximately 6"x6") with angle slots for use as carriage in photomicrographic installation. Stock item preferred. A-384

Hydroponics Controls

Reader wishes to get information on controls and systems for hydroponics on a small scale. A-385

D-c Watthour Meters

Senior engineer with utility company seeks portable multirange watthour meters (rotating standards) for 120 and 240 v, and 1 to 50 amps. A-386

Photoelectric Pyrometer

Manager of electronic wholesale distributor seeks photoelectric pyrometer which can read surface temperatures of aluminum in the range of 500 to 1300°F. A-387

Pressure Filter

Research librarian in chemical company seeks source of supply for laboratory-type pressure filter with 150-200-ml capacity, good for 1000 psi and 200°F. A-388

Hydrogen in Liquid Metal

French instrument manufacturer seeks to identify maker of Telegas-Meter to measure the content of hydrogen in liquid aluminum and copper alloys. A-389

NOW!

A BRAND-NEW CONCEPT IN FLOW TOTALIZING!

Continuous . . .

Pneumatic . . . ***FLYBALL*** **INTEGRATOR**

Inherently Accurate!

- Eliminates Inaccurate "Spot Check" Counting!
  Continuous integration assures highest precision.
- Eliminates Cam and Linkage Errors!
  Unique design balances differential pressure signal directly against centrifugal force.
- Eliminates Calculations!
  Automatically extracts square root — shows totals in desired units.
- Eliminates Fire and Explosion Hazards!
  Simple, all-pneumatic operation requires no electric motors, wires, or contacts.

FOXBORO
REG U S PAT OFF

Now you can integrate all your plant flow measurements, including oxygen . . . *continuously* . . . with new accuracy . . . complete safety! The all-pneumatic Foxboro Flyball Integrator completely eliminates intermittent counting and fire hazard. Its simple, force-balance operation utilizes the 3-15 psi air signal from any conventional differential-pressure flow transmitter. This signal is *continuously* balanced against the "flyball" force of the instrument's pneumatically-driven turbine. The square root function is automatically extracted . . . you read flow totals *directly*.

The Flyball Integrator mounts at the point of measurement or on a panel hundreds of feet away. Response and accuracy are completely unaffected by ambient temperature changes or pressure changes in turbine air supply. Ideal solution to all plant fluids accounting and in-process inventory checking. Write for complete details. **The Foxboro Company, 464 Norfolk Street, Foxboro, Mass.**

FIRST IN FLOW

For more information circle **13** on inquiry card.

"I know my product does better than this... but how can I prove it?"

Yes, your customers are *always* right . . . *when there's no proof to the contrary*. But when you can prove *on the record* that performance is up to guarantee, then there's no further argument. And you can give them that record by building into your product a Veeder-Root Counter as a standard, integral part . . . to count in any terms or units your customers could want. This is easy to do . . . and inexpensive, too. Let us figure it out for you. Write.

You always "Know the score" when you count on Veeder-Root!

NEW
High Speed, Quick Reset REVOLUTION COUNTER

This is one of scores of types of counters made by Veeder-Root for manual, mechanical and electrical counting. This counter runs at speeds up to 6,000 rpm . . . resets to zero with one flick of the lever. Also available with predetermining feature.

Everyone can Count on VR®

Veeder-Root Inc.

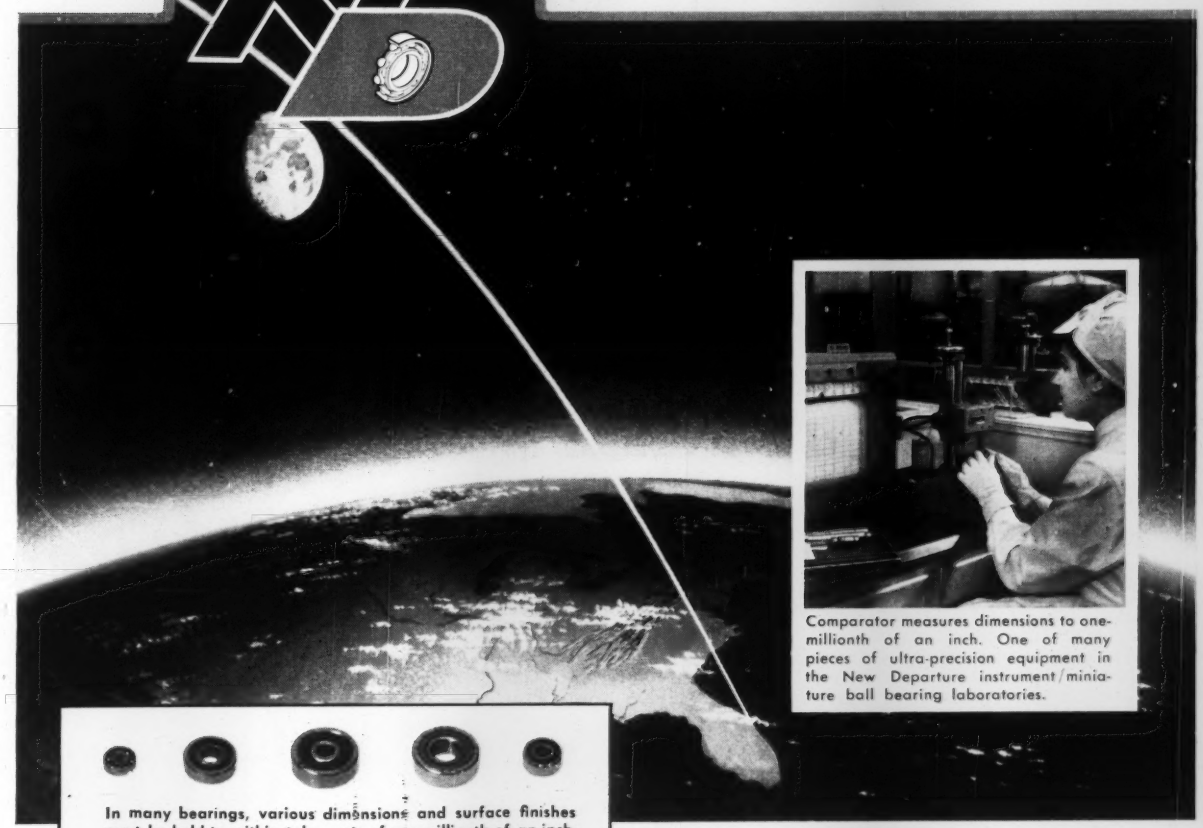
Hartford 2, Connecticut

Hartford, Conn. • Greenville, S. C. • Altoona, Pa. • Chicago
New York • Los Angeles • San Francisco • Montreal

Offices and Agents in Principal Cities

For more information circle **14** on inquiry card.

CASE HISTORIES



Comparator measures dimensions to one-millionth of an inch. One of many pieces of ultra-precision equipment in the New Departure instrument/miniature ball bearing laboratories.

In many bearings, various dimensions and surface finishes must be held to within tolerances of one millionth of an inch.

Instrument Ball Bearings Help Missiles Along A Bright Path Of Precision!

CUSTOMER PROBLEM:

Missile guidance system manufacturers require a dependable source for super precise instrument ball bearings. When used in spin axis and gimbal applications, for example, these ball bearings help restrict vitally important drift, through extremely close tolerances and high precision uniformity.

SOLUTION:

New Departure research, development and production facilities were applied to solving the vital problem. Visual evidence of New Departure's success is the bright path of precision written across the skies by Sperry, AChiever and other guidance systems used in many of the most advanced missiles and space craft. In the case of Sperry's gyrosyn guidance system, for example, New Departure instrument ball bearings are credited with a remarkable 1200% gain in gyro accuracy. Proof enough that New Departure has the know-how and facilities to solve tomorrow's instrument/miniature ball bearing design problems in missile and space exploration.

What's more, these New Departure facilities are available for *your* design development right now! Call or write Department I-4.

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

For more information circle **15** on inquiry card.

Only from Parker

so complete a range of tube fittings for process and instrument lines

Select the proper tube fittings for any of your process or instrumentation lines from hundreds of different sizes, shapes and alloys in the Parker fittings line.

Parker "Intru-lok" fittings for fast, easy assembly of low- and medium-pressure lines in metal or plastic tubing. Fittings come ready to use without disassembly.

"Triple-lok" flare-type fittings make up leak proof on high pressure, high temperature lines. They are ASME-approved, ideal where safety is vital.

Leak-free, vibration-proof "Ferulok"® flareless, bite-type fittings hold pressure-tight on thin-wall or heavy-wall steel or stainless tubing. For semi-permanent joints on critical applications, use "Braze-lok" fittings on O.D. tubing. And use "Weld-lok" for highest temperatures and pressures.

Call your Parker fittings distributor for prompt delivery of Parker fittings from local stocks. He can also offer expert advice on any process or instrument tubing installation.

Parker FITTINGS AND HOSE DIVISION

17325 Euclid Avenue • Cleveland 12, Ohio

A DIVISION OF PARKER-HANNIFIN CORPORATION

For more information circle **16** on inquiry card.

Federal budget for scientific research & development for fiscal 1959 is expected to be $715 million above budget estimate, reports NSF (in NSF-58-39) as follows:

Table 2.—ESTIMATED OBLIGATIONS FOR CONDUCT OF RESEARCH AND DEVELOPMENT, FISCAL YEAR 1959

(Thousands of dollars)

Agency	Estimates based on The Budget, 1959[a]	Revised estimates, November 1958[b]
Total all agencies	$3,544,694	$4,258,927
Department of Agriculture	113,481	114,531
Department of Commerce	27,055	29,055
Department of Defense[c]	2,450,255	2,960,911
Department of the Army	467,760	561,753
Department of the Navy	641,045	756,060
Department of the Air Force	719,000	777,914
Departmentwide funds	428,050	670,784
Pay and allowances of military personnel in R & D	194,400	194,400
Department of Health, Education, and Welfare	184,635	238,168
National Institutes of Health	(156,968)	(210,501)
Department of the Interior	53,292	56,236
Atomic Energy Commission	545,809	623,579
National Aeronautics and Space Administration	70,880	123,500
National Science Foundation	42,784	56,444
All other agencies[d]	56,503	56,503

More than 1000 IBM 650's have been delivered throughout the world; more than 70 IBM 705's.

Process instrument market depends on industrial capital spending programs, says Black, Sivalls & Bryson in annual report, which gives following data: wells drilled in 1958 (est.) numbered 52,134 (3% under 1957). Natural gas demand has doubled since 1954 and is still growing. U.S. restriction on crude oil imports has curtailed Canadian and Venezuelan production—Canada drilled 2700 wells in 1958 (down 7%); Venezuela 1500 wells (down 19%). Crude oil reserves in U.S. have exceeded 33 billion barrels; gas reserves have increased to 249 trillion feet. Oil consumption in free world is expected to rise 50% in next 10 years.

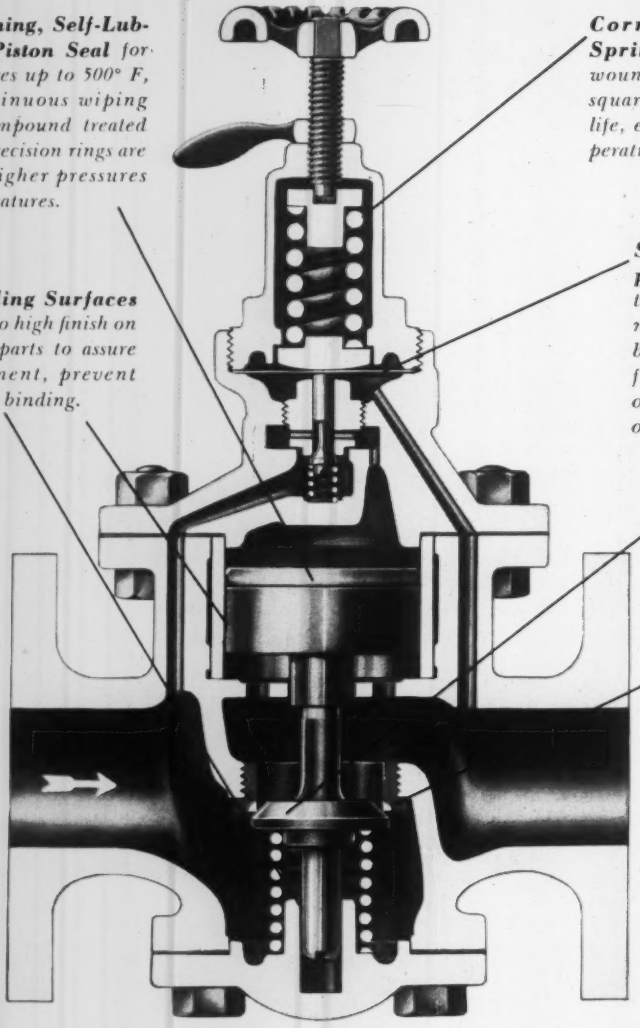
Electronics volume in 1959 will reach $8.3 billion, compared to $7.7 billion in 1958, says W. Cooley, Television Shares Management Corp. The $7.7 billion includes $4.1 billion military, $1.4 billion commercial and industrial, $1.3 billion entertainment, says Cooley.

R. E. Lewis, Pres. of Sylvania Electric, makes following 1959 forecasts: Electronics market over-all volume $14.3 billion (compared with $13 billion in 1958 and $13.3 billion in 1957); may reach $25 billion by 1970. Gross national product in 1959 will be $465 billion ($29 billion above 1958); disposable income $325 billion (up $14 billion from 1958); consumer spending $305 billion (up $14 billion). Industrial and commercial electronics market to rise above $1.5 billion (up $150 million over 1958) of which $450 million is computers and EDP equipment. Military electronics market will be close to $4 billion in 1959 (compared to $3.8 billion in 1958). Residential power sales will jump 9% in 1959 to more than 174 billion kilowatt-hours.

HERE'S WHY YOU GET EXTRA VALUE COMPLETE LINE OF

Self-Cleaning, Self-Lubricating Piston Seal *for temperatures up to 500° F, gives continuous wiping action. Compound treated cast iron precision rings are used for higher pressures and temperatures.*

Long Guiding Surfaces *are ground to high finish on all moving parts to assure true alignment, prevent cocking and binding.*



Corrosion-Resistant Springs *are accurately wound with ends ground square. Maximum spring life, even under high temperature conditions.*

Stainless Steel Diaphragm *responds instantly to any flow change—eliminates stuffing boxes and bellows seals. Diaphragm's full travel is less than its own thickness, can't be over-stressed.*

Single Seated Construction *assures positive dead end shut off.*

Stellited Seating Surface *combined with a hardened stainless main valve provides ultimate in erosion resistance.*

Interchangeable parts *May be replaced without taking valve body off the line, and, even more important, without machining.*

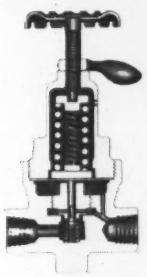
Cutaway of Leslie internal pilot, piston operated reducing valve class LY, shows typical Leslie quality construction features. Throughout the Leslie line, features like these and others presented on the next page are your assurance of lower operating costs and long life performance. They are based on over 50 years of leadership in designing and manufacturing quality regulators.

Internal pilot piston operated reducing valves are available for steam services, up to 2500 lbs., ASA, reduced pressure ranges to 1400 psi. Sizes ½ to 6". Cast iron, bronze, steel or alloy steel construction.

LC-9

For more information circle **17** on inquiry card.

IN LESLIE'S REDUCING VALVES AND REGULATORS



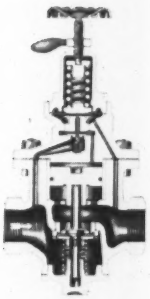
LESLIE SMALL FLOW REDUCING VALVES

Leslie small flow reducing valves are used in pilot plant operations, plastic molding presses, laboratory units, gland sealing, steam sterilization and atomizer units and wherever control of small flows of steam, air, gas or non-corrosive liquids are a problem.

These ½" valves feature simple, direct operated design with screwed or bolted adjusting spring assembly for easy access to the internal parts. No stuffing boxes or fussy seals.

PRESSURE-TEMPERATURE RANGES

BODY MATERIALS AND CONSTRUCTION	CLASS	MAX. INLET PRESSURE PSI		MAX. TEMP. °F	MIN. PRESS. DROP PSI	REDUCED PRESS. RANGE PSI
		STEAM	COLD LIQUID AIR OR GAS			
BRONZE Screwed Bonnet	LCA	—	400	150	10	5-285
	LCB LCC LCD	300	400	550	10	10-285
	LCLA	—	400	150	10	2-35
	LCLB LCLC LCLD	300	400	550	10	2-35
STEEL Thru bolted Bonnet	LCL(B)S LCL(C)S LCL(D)S	600	1000	750	10	25-400 10-50



LESLIE REDUCING VALVES FOR AIR OR GAS SERVICE

Leslie internal pilot, piston operated reducing valves offer a combination of accurate regulation and low maintenance service, and are used for accurate control of air or gas with inlet pressures up to 400 psi at 150° F.

Accuracy of regulation is comparable to instrument control with full flow for equivalent pipe size. Valves feature 99% accuracy of regulation at rated capacity.

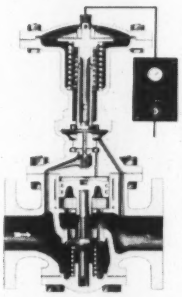
Positive, bubble tight shut-off is provided by resilient, single seated valve disc. Fully guided main valve, stainless steel diaphragm and non-corroding internal springs assure long, trouble-free operation.

PRESSURE RANGES AND CONSTRUCTION

CLASS	SIZE (Inches)	MAXIMUM INLET PRESSURE & TEMP.	REDUCED PRESSURE RANGE PSI		BODY MAT'L	END CONNECTIONS
			MIN.	MAX.		
LA-5 LAE-5	½-4	25-400 psi 150° F max.	5*	285	Bronze	½-2" 300 lb. screwed ½-4", 150 & 300 lb. MSS flanged
LAK LAEK		25-400 psi 150° F			Cast Iron	½-2" 250 lb. screwed 1½-3" 250 lb. ASA flanged
		25-175 psi 150° F max.				1½-4" 125 lb. ASA flanged

*5% of inlet pressure over 100 psi

REMOTELY ADJUSTED REDUCING VALVES



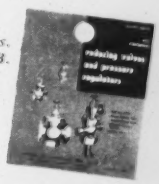
Operating characteristics of Leslie remotely adjusted reducing valves are identical to manually adjusted types. The remotely adjusted reducing valve is adjusted to the desired pressure setting by air pressure from an air loading device. The constant loading force on the upper diaphragm opens the pilot valve and is balanced by a constant reduced pressure proportional to the loading force.

The air loading panel eliminates hazardous or inconvenient adjustments and provides fast means of readjusting pressure to meet changing requirements.

REMOTELY ADJUSTED REGULATING VALVES

TYPE	SIZES AVAILABLE (Inches)	BODY MATERIALS AVAILABLE	INLET PRESSURE RANGES (PSI)	MAXIMUM REDUCED PRESS. (PSI)
Small flow, internal pilot actuated, diaphragm operated	¼, ⅜, ½	Bronze	20-300 psi 550° F steam 20-400 psi 150° F air	175
Internal pilot actuated, piston operated	½ - 6	Cast Iron Bronze Cast Steel	25 psi up to 600 psi, 750° F	175
Internal pilot actuated, piston operated for high pressure service	½ - 3	Cast Steel and Alloy Steels	300 psi up to 3000 psi	700

For sizing and capacity data on this Leslie line of valves, contact your Leslie engineer or write for Bulletin 5302B.



TRADE LESLIE MARK

REGULATORS and CONTROLLERS

Leslie Co., 499-A Leslie Building, Lyndhurst, New Jersey

Over 275 Factory-Trained Engineers At Your Service—Nationwide!

For more information circle **17** on inquiry card.

news

Performance of Magnetic Tape

WASHINGTON, D. C.—The National Bureau of Standards is investigating the performance of magnetic tape in a program aimed at formulating standardization tests. Progress in testing allows tape to be evaluated without reference to an individual recording machine.

The test sample, a tape of known magnetic area, is anhysteretically magnetized in a solenoid energized with a small direct current and a large alternating current. The remanent magnetization in the sample, after the currents are reduced to zero, is measured by passing the

sample through a search coil connected to a fluxmeter. Reduction of the currents to zero takes place in two modes: (1) the gradual reduction of the ac to zero before removing the dc; and (2) the simultaneous gradual reduction of ac and dc to zero.

The behavior of a given tape can be expressed in terms of two constants: the anhysteretic susceptibility, which is the ratio of the maximum remanent magnetization at a high a-c field amplitude to the d-c field strength; and the critical field strength, which is the a-c field amplitude required to achieve half the maximum remanent magnetization.

The tape-containing tube is rapidly passed through the smaller search coil after having been magnetized in the large coil. The remanent flux is read from the upper part of the unit which is an electronic equivalent of a ballistic galvanometer.

Automated Refinery

PORT ARTHUR, TEXAS—Early in April, a Thompson-Ramo-Wooldridge RW-300 digital computer took over control of a $4-million refining unit of Texaco's huge Port Arthur Refinery. This is the "first industrial process ever to be controlled by a computer." Efficiency increase of 6% to 10% is hoped for. Information from 110 sources will be used to control 16 different streams pressures, and temperatures.

Another "first" will be the use of two RW-300 computers to detect and locate ruptured cartridges in the first commercial nuclear power plant being constructed near Chinon by Electricité de France.

Pgh. Analytical Conference

PITTSBURGH, PA.—Infrared spectroscopy is probably the most powerful *qualitative* instrumental technique now available in terms of numbers and types of applications; the new sensitivities becoming available with gas chromatography may make this technique the most powerful *quantitative* technique. In both infrared and chromatography, Perkin-Elmer unveiled important new developments at the Pittsburgh Analytical Conference.

In infrared, the new technique of the Perkin-Elmer Model 221 Infrared Spectrophotometer involves the ingenious use of a prism plus a grating wherein the grating acts like a Littrow mirror above 7 microns. Result: a linear scan from 2.5 to 15 microns with a resolution of 2 to 3 wave numbers—and at a price under $15,000.

In chromatography, the exciting new news involves new detectors (ionization type) and new columns (capillary types, called Golay by Perkin-Elmer). Result: sensitivity of parts per million, higher resolution, and need for only microgram samples.

Many other new instruments were unveiled at the conference, including (1) Philips Electronics portable x-ray spectrograph, (2) CEC electrolytic-coulometric technique for measuring moisture levels to 1 ppm, (3) Baird-Atomic direct-reading spectrograph, (4) Sargent polarograph, (5) Axler colorimeter, and many others. All of these instruments will be reviewed in a special series of articles now in preparation for *Instruments & Control Systems*.

Automated Power Plant

NEW YORK, N. Y.—A new 225,000-kw facility, to be constructed at Little Gypsy, La., for Louisiana Power & Light Company, will be the first fully-automated electrical power generating station. It will be capable of supplying the electrical requirements of a city of over 200,000. An electronic computer system, with 4000 transistors and

more than 7000 diodes (designed and built by Daystrom Systems) will control all phases of operation—from start-up through operation to shut-down. The computer will scan 700 different temperatures, pressures, flow rates, and valve and switch positions.

Picture shows Chalmer E. Jones (left), general manager, Daystrom Systems, with Kemp W. Reece, executive vice president of Ebasco Services, Inc., designers and constructors of the facility.

Now there's a New "Jeweled" Escapement in ROCKWELL CHART DRIVES

for greater accuracy and longer life

This jeweled movement brings fine watch quality to instrument timing

The introduction of a jeweled movement—the first ever used on a general industrial timing device made in the United States—makes the Rockwell more accurate than any unjeweled chart drive could possibly be. In addition to offering fine watch quality, the jeweled escapement requires less power to operate and is extremely durable, since seven hard jewel surfaces are provided to limit friction and wear.

You will benefit in many ways by using these jeweled movement chart drives for powering all your recording instruments. They adapt readily to fit into practically any instrument case while speed-changing turrets (see left) permit changing rotation rates at will. Write for full information. Rockwell Manufacturing Company, Instrument Division, Pittsburgh 8, Pa.

SPEED CHANGING TURRETS PROVIDE SEVEN DIFFERENT ROTATION RATES

The basic Rockwell Chart Drive has a main arbor rotation rate of 7 days. Economical snap-on turrets permit changing to 8-day, 15-day, 16-day, 24-day, 30-day, 31-day, and 24-hour rotation. No tools or special skills are required. You can even change chart rotation without removing the drive from the instrument.

JEWELED CHART DRIVES

another fine product by

ROCKWELL

For more information circle 18 on inquiry card.

$$\int_V (\nabla T)^2 \, dy = \int_S T(\nabla T \cdot n) \, ds$$

SPACE-AGE OPENINGS FOR ANALOG ENGINEERS

Expanding space-age projects at Boeing have created a number of exceptional opportunities for COMPUTER ENGINEERS. Among the projects offering long-term careers are boost-glide vehicles, anti-ballistic missiles, interplanetary systems, manned and unmanned space vehicles.

Openings are available *now* in two general areas:

Senior Analog Computing Engineers

... To extend the application of analog techniques to new problems arising from space-oriented design, development and research. Industrial experience, research experience and advanced degree preferred.

Analog Computing Engineers

... To assist in the formulation, analysis, and solution of problems by use of Analog Equipment. Sample problem areas: Stress Analysis, Guidance Systems, Heat Transfer. Degree and related experience required.

At Boeing you'll enjoy a host of benefits, including insurance and retirement programs, relocation allowance, high pay, and plenty of opportunity for advancement.

Write today, to:

Mr. Stanley M. Little
Boeing Airplane Company
P.O. Box 3822 - IAA
Seattle 24, Washington

BOEING

For more information circle **19** on inquiry card.

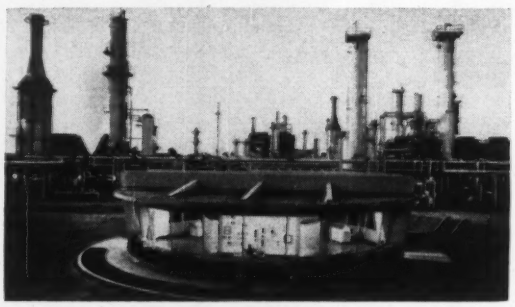
NEWS—CONTINUED

HAGAN CHEMICALS & CONTROLS has been awarded a quarter-million-dollar contract for controls, instrumentation and data processing equipment on the largest steam boiler in the world to be used at the Tennessee Valley Authority Widow's Creek Station in Stevenson, Alabama, rated at 3,850,000 pounds of steam per hour and powering a turbine with an output of 500,000 kwh. Hagan's Kybernetes division will supply a new Series 2000 data processing system for the unit including a scanner which continuously monitors and records 475 variables such as temperatures, flows and pressures.

BIMCAM (the British Industrial Measuring & Control Apparatus Mfr.'s Assoc.) held its Annual Luncheon in London on January 20, at which Sir Ewart Smith, a Deputy Chairman of Imperial Chemical Industries Ltd.,

spoke of the growing importance of instrumentation in the process industries. Sir Ewart is shown in the center, with Sir Arnold Hall, president of the Royal Aeronautical Society on his right, and Mr. L. S. Yoxall, president of BIMCAM, on his left.

BLAW-KNOX COMPANY's Tulsa Division designed a novel refinery control center for the La Gloria Oil and Gas Company's Tyler, Texas, refinery. The circular, air-



conditioned building with double glass insulating walls enclosing a room approximately 50 feet in dia. contains three graphic control panels. Instrumentation is by Fischer & Porter Co.

LOYOLA UNIVERSITY's College of Commerce, Chicago, is the first business school in the country to offer its students an integrated survey course in automation theory and computer techniques, logic, and modern mathematics.

MAGAMP has been ruled by the Assistant Commissioner of Patents as a contraction and commonly used in lieu of magnetic amplifier, so that no company is entitled to register the term as a trademark.

First Digital Voltmeter With Mathematically Perfect Logic . . .

The first stepping switch voltmeter with mathematically perfect logic . . . and the first to be completely transistorized! It's the NLS V-34, the latest instrument to be developed by the originators of the digital voltmeter. The exclusive new digital logic of the NLS V-34 allows readings to be made without cycling stepping switches through all nine positions in each decade. For the first time, "needless nines" are eliminated . . . the result: longer switch life and shorter measuring time. Check the exclusive features listed below.

"NO NEEDLESS NINES"

FOR FASTER MEASUREMENTS AND GREATEST RELIABILITY

MATHEMATICALLY PERFECT LOGIC — No numbers change that absolutely do not have to change. Stable measurements can be made of varying voltages.

STEPPING SWITCHES SEALED IN OIL — Each stepping switch is mounted in an individual oil-filled container. No manual lubrication needed. Oil bath extends life by factor of ten.

PLUG-IN STEPPING SWITCH MODULES — Stepping switches can be replaced as quickly as plugging in the meter.

FIRST COMPLETELY TRANSISTORIZED DIGITAL VOLTMETER — Even logic functions are performed by semi-conductors. Switch points reduced to one-half those required by "completely transistorized" competitive meters. Only the NLS V-34 is transistorized to the fullest possible extent.

SPECIFICATIONS

Range to ±1000 volts . . . Ratio to ±.9999 . . . 10 Megohm input impedance . . . 0.01% accuracy . . . Automatic range and polarity changing . . . five-digit model also available.

Write today for complete information on the NLS V-34

Originators of the Digital Voltmeter

non-linear systems, inc. DEL MAR (San Diego), CALIFORNIA

1959 IRE SHOW — Booths 3041-2

COMPARISON CHART

The few steps required by the NLS V-34 to make a typical measurement (3rd column) are compared with the many required by competitive meters. Note the blue "needless nines" in the middle column.

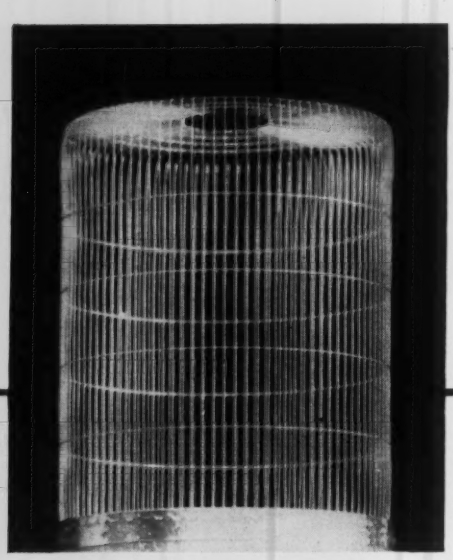
NO. OF STEPS	COMPETITIVE METERS	NLS V-34
0	+.8888	+.8888
1	+.8889	—.8888
2	+.8880	—.9888
3	+.8890	—.0888
4	+.8800	—.1888
5	+.8900	—.1988
6	+.8000	—.1088
7	+.9000	—.1188
8	+.0000	—.1198
9	—.0000	—.1108
10	—.0001	—.1118
11	—.0002	—.1119
12	—.0003	—.1110
13	—.0004	—.1111
14	—.0005	
15	—.0006	
16	—.0007	
17	—.0008	
18	—.0009	
19	—.0019	
20	—.0029	
21	—.0039	
22	—.0049	
23	—.0059	
24	—.0069	
25	—.0079	
26	—.0089	
27	—.0099	
28	—.0199	
29	—.0299	
30	—.0399	
31	—.0499	
32	—.0599	
33	—.0699	
34	—.0799	
35	—.0899	
36	—.0999	
37	—.1999	
38	—.1099	
39	—.1199	
40	—.1109	
41	—.1119	
42	—.1110	
43	—.1111	

THE MEASUREMENT IS COMPLETED IN JUST 13 STEPS BY THE NLS V-34

NLS — The Digital Voltmeter That Works . . . And Works . . . And Works!

For more information circle **20** on inquiry card.

platinum clad tungsten wire is most efficient for high temperature applications



Platinum clad tungsten wire is ideally suited to modern requirements for high power vacuum tube grid and other high temperature applications. Because of its superior physical properties at elevated temperatures, tungsten provides the more rigid, refractory core material required by high power tubes; it also exhibits lower interaction with platinum. Unlike molybdenum, platinum clad tungsten is readily hot-stretched to take a permanent setting and lends itself to fabrication into grids employing conventional fixtures and spot welding procedures. Available in diameters from .001" and up. Write for Technical Bulletin.

BAKER PLATINUM DIVISION • 113 ASTOR STREET
NEWARK, N. J.

precious metal contacts for high-reliability

For high-reliability and long operating life, precious metal contacts in pure or alloyed forms of silver, platinum, palladium and gold are very definitely indicated. These contacts provide unmatched high resistance to atmospheric corrosion, deformation, arc erosion, binding and metal transfer. Baker precious metal contacts are supplied as wire, rod, sheet and in a complete line of fabricated forms. Facilities are also available for manufacture to your specifications. Write for Baker Contact catalog.

BAKER CONTACT DIVISION • 207 GRANT AVE., E. NEWARK
HARRISON P. O., N. J.

BAKER PLATINUM DIVISION

WRITE FOR LITERATURE

BAKER CONTACT DIVISION

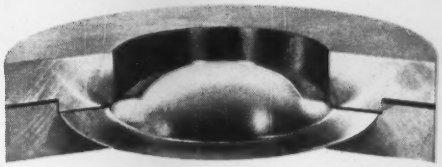
DOMESTIC DIVISIONS: AMERICAN PLATINUM & SILVER DIVISION, AMERSIL QUARTZ DIVISION, BAKER CONTACT DIVISION, BAKER DENTAL DIVISION, BAKER SETTING DIVISION, BAKER PLATINUM DIVISION, CHEMICAL DIVISION, EAST NEWARK INDUSTRIAL CENTER, HANOVIA LAMP DIVISION, HANOVIA LIQUID GOLD DIVISION, IRVINGTON-BAKER REFINING DIVISION, D. E. MAKEPEACE DIVISION, NATIONAL ELECTRIC INSTRUMENT DIVISION, RESEARCH AND DEVELOPMENT DIVISION, H. A. WILSON DIVISION. COMPANIES ABROAD: ENGELHARD INDUSTRIES OF CANADA, LTD. TORONTO, ENGELHARD INDUSTRIES OF QUEBEC, LTD. MONTREAL, ENGELHARD INDUSTRIES, LTD. LONDON, ENGELHARD INDUSTRIES A. G. ZURICH, ENGELHARD INDUSTRIES PTY., LTD. MELBOURNE, SOCIEDAD SURAMERICANA DE METALES PRECIOSOS S. A., BOGOTA, INDUSTRIE ENGELHARD S. P. A. ROME, ENGELHARD INDUSTRIES OF SOUTHERN AFRICA, LTD. JOHANNESBURG. ASSOCIATED COMPANIES: ACME TIMBER INDUSTRIES LTD., SOUTH AFRICAN FOREST INVESTMENTS LTD., SOUTH AFRICA, AZOPLATE CORPORATION, CHARLES ENGELHARD, INC., NUCLEAR CORP. OF AMERICA, INC., U.S.A.

For more information on wire circle **21** on inquiry card.
For more information on contacts circle **22** on inquiry card.

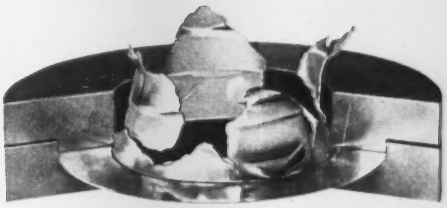
for low cost purification and drying of hydrogen and other gases

The Deoxo Catalytic Purifier is combined with an extremely efficient automatically operated drying unit to provide oxygen-free hydrogen that is ideally pure and dry. The combined units are identified as the Deoxo Dual Puridryer. It supplies hydrogen with less than one part oxygen per million — dried to a dew point of —100°F. *No inert gas purging is needed.* The Deoxo Dual Puridryer can also be used with other gases such as: Nitrogen, Argon, Helium and saturated hydrocarbons, with equally fine performance. Write for descriptive literature.

CHEMICAL DIVISION • 113 ASTOR STREET
NEWARK, N. J.



corrosion-resistant rupture discs for dependable instant and automatic relief of excess pressure



In pressurized apparatus subject to corrosive action, precious metal rupture discs provide the safest, most accurate and dependable relief. Platinum, gold, and silver are now generally recognized as specifics when dealing with corrosion. Each is resistant to the corrosive effects of an important group of liquids and gases and will remain unattacked under conditions that would render many base metal materials useless. These rupture discs, depending on material selected, are guaranteed to be burst ± 5% of specified pressure. Intrinsic value adds to the original cost of these discs but the actual metal value is recovered, no matter how torn or battered the discs may be. Send for Bulletin.

BAKER PLATINUM DIVISION • 113 ASTOR STREET
NEWARK, N. J.

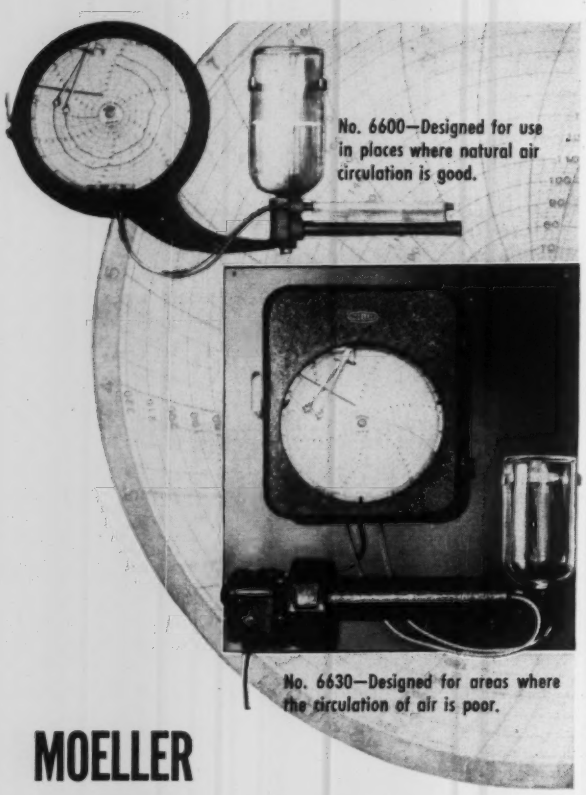
CHEMICAL DIVISION

ENGELHARD INDUSTRIES, INC.

EXECUTIVE OFFICES:

113 ASTOR STREET • NEWARK 2, NEW JERSEY

For more information on Deoxo circle **23** on inquiry card.
For more information on rupture discs circle **24** on inquiry card.


No. 6600—Designed for use in places where natural air circulation is good.
No. 6630—Designed for areas where the circulation of air is poor.

MOELLER
RECORDING PSYCHROMETERS...

With and Without Motor Driven Fan

Record Wet and Dry Bulb Temperatures for Determining Relative Humidity

More than 90 years of experience in design and production are built into the manufacture of these fine precision instruments. Unfailing standards of Moeller craftsmanship provide accurate relative humidity determinations and the invaluable advantage of a reliable permanent record. The choice of units available depends upon air circulatory conditions, AC or DC voltage supplies, and close or remote readings.

Mail the coupon today for complete details!

MOELLER INSTRUMENT COMPANY SINCE 1867
32nd ST. and 89th AVE. • RICHMOND HILL 18, N. Y.
Representatives in Principal Cities

Gentlemen: Without obligation, please send me Catalog No. 150 on Moeller Psychrometers.

NAME .....

FIRM .....

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CITY..... ZONE..... STATE .....

For more information circle **25** on inquiry card.

stock report

Any further information concerning any of the following issues may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

American Stock Exchange:

AMERICAN STOCK EXCHANGE
Price Range 1958-59 Thru March 16, 1959

	HIGH	LOW	PRICE AS OF 3/16/59
American Meter	45	27 5/8	40 3/4
Arc Equipment	29 3/4	13 3/4	27 5/8
Barry Controls "B"	22 1/2	4 3/8	21 5/8
Belock Instruments	15 7/8	7 3/8	15 1/8
Benrus Watch	7 1/2	4 7/8	7 1/2
Breeze Corp.	8 7/8	5 1/8	8
Clark Controller	24	14 7/8	22 3/8
Clarostat Mfg.	7 1/4	2 7/8	6 1/8
Clary Corp.	8 1/4	2 7/8	7 7/8
DuMont Laboratories	8 1/4	3	7 5/8
Dynamics Corp. of America	8 1/2	2 7/8	8 1/8
Electronics Corp. of America	16 1/4	6 3/8	15 5/8
El-Tronics	3 3/4	5/8	1 5/8
Fairchild Camera & Instrument	95 7/8	19 1/2	91 5/8
General Transistor	17 1/4	17 1/4	12 1/4
Globe-Union	24 3/8	14 5/8	24 3/8
Hazeltine Corp.	64 3/4	30 1/2	64 3/8
International Resistance	10 1/2	3 3/4	9 5/8
Laar Inc.	14 1/8	4 1/4	12 1/2
National Research	28 1/2	12 7/8	26
Neptune Meter	39 5/8	19 1/2	37
New Haven Clock	3 1/4	7/8	3
Nuclear Corp. of America	2 1/4	7/8	1 1/2
Philips Electronics Inc.	36 7/8	11	31 5/8
Pneumatic Scale	67	26 1/2	43 3/4 (1)
Servo Corp. of America	43 1/2	6 3/4	36
Servomechanisms	28 1/4	6 5/8	25 5/8
Statham Instruments Inc.	40 1/4	15 5/8	36 7/8
Victoreen Instrument Co.	12	3 3/4	11 1/8
Wallace & Tiernan	40 3/4	24	38 1/2
Waltham Prec. Instrument Co.	2 7/8	13/16	2 3/4

1) Not Traded - Bid and Asked

New York Stock Exchange:

NEW YORK STOCK EXCHANGE
Price Range for 1958-59 Thru March 16, 1959

	HIGH	LOW	PRICE AS OF 3/16/59
ACF Industries	58 1/4	37 1/8	54 3/8
Aeroquip Corp.	29 3/4	16 7/8	29
Allis Chalmers	50 7/8	22 1/8	29 3/4
American Chain & Cable	55 1/2	39 1/2	54 1/2
American Machine & Foundry	72 3/4	32 1/4	69
American Machine & Metals	84	47 1/2	79 1/4
American Optical	49 1/2	34 3/4	45
American Tel. & Tel.	247 1/2	167 7/8	242 3/4
Ampex Corp.	84 1/2	47 3/4	76 1/4
Bausch & Lomb Optical	45	23	26 5/8
Beckman Instruments	55 1/2	28 1/8	51
Bell & Howell	94 7/8	42	91 1/4
Bendix Aviation	79 3/4	44 1/2	79
Boeing Airplane	58 1/8	34 1/8	40 1/4
Bullard	20 3/4	10	18 1/4
Bulova Watch	20 1/4	9 3/4	17 7/8
Burroughs	43 1/2	27 5/8	41 1/8
Carborundum	43 3/4	30 7/8	41 5/8
Cincinnati Milling Machine	44 1/2	27	40 1/4
Clevite	38 3/8	15 3/4	30 3/4
Columbia Broadcasting System	41 7/8	24 1/8	40 3/4
Consolidated Electrodynamics	47 1/2	27 7/8	39
Consolidated Electronics	44 3/4	19 1/2	38 1/8
Cornell Dubilier	26 3/4	12 3/4	24 1/8
Corning Glass	110	74 5/8	106 1/4
Curtiss-Wright	33 5/8	20 5/8	30 7/8
Cutler-Hammer	69 3/4	40 1/2	64 1/2
Daystrom	45 1/8	30	44 3/8
Douglas Aircraft	74 7/8	50 1/8	55 3/8
Eastman Kodak	155 1/4	97 1/8	155
Eaton Mfg.	68 1/4	38 1/2	66
Electric Auto Lite	42	25	41
Elgin Watch	12 5/8	6 3/4	12 1/8
Emerson Electric	60 1/8	29	55 1/2
Food Machinery & Chemical	46 1/4	35 1/4	45 1/4
Gamewell	39 1/4	20 1/2	34 1/8
Garrett	45 1/2	27	43 5/8
General Controls	54 3/8	14	53 1/2
General Dynamics	67 3/8	55	61 5/8
General Electric	83 7/8	57	82 1/4
General Instrument	22 3/8	4 5/8	20 1/2
General Mills	100 3/8	60 1/4	104 3/4
General Precision Equipment	42 1/2	27	39 1/4
General Railway Signal	39 1/4	21 1/8	39
General Telephone & Elec.	73 3/4	40 3/8	67
General Time	75	16 5/8	68 1/4
General Tire & Rubber	74 1/2	22 1/4	66 3/4
International Business Machines	552	300	525 1/2
International Tel. & Tel.	42 1/2	26	40 5/8
ITE Circuit Breaker	47 1/2	24 3/4	46 7/8
Litton Industries	96 1/2	56 7/8	90
Lockheed Aircraft	34 1/2	26 5/8	33
Magnavox	60 1/2	30 1/4	59 1/4

Continued on page 491

FOR MORE INFORMATION ON ANY OF THE PRODUCTS REPORTED OR ADVERTISED IN THIS ISSUE, CIRCLE THE ITEM NUMBER ON THE INQUIRY CARD ON PAGE 291. IF THE CARD HAS ALREADY BEEN USED, WRITE NUMBER; DATE OF ISSUE; YOUR NAME, ADDRESS, COMPANY, PRODUCTS MANUFACTURED ON A POSTAL CARD. MAIL C/O READER SERVICE.

PARTS/BILLION
detection of gases and vapors in air or process streams

It's feasible now with new ionization instrument from MSA

such acid gases as:
HCl · HF · SO_2 · HCN · N_2O_4
such alkaline gases as:
ammonia · hydrazine · amines
such halogenated chlorinated hydrocarbons as:
carbon tetrachloride · trichloroethylene
ethylene chloride · ethylene bromide
and some insecticides
and in addition:
nickel carbonyl · tetra-ethyl lead
and even oxygen in non-electro-negative gases

. . . the M-S-A® BILLION-AIRE* ANALYZER continuously indicates and records contaminants listed above in the range of parts per billion to parts per million

PRINCIPLE OF OPERATION

For all of the above listed applications except oxygen measurement, the gas of interest is converted to an aerosol before introduction into the measuring system.

The M-S-A Billion-Aire measures electrically, in a specially designed ionization chamber, any decrease in the conductivity of the treated gas samples caused by removal of ions by the particulate. A radioactive material (of a strength comparable to a luminous watch dial) in the chamber produces continuous ionization.

VERSATILITY

As the name implies, the M-S-A Billion-Aire continuously measures traces of gases and vapors in the parts per *billion* range. We could rattle off a hundred and one uses for this unique ionization detection system if space permitted. Its scope of capabilities is extremely widespread.

SELECTIVITY

Various sensitizing techniques assure a wide range of selectivity. This new instrument already detects a substantial number of gases and vapors. The number increases as more and more new sensitizing techniques are introduced.

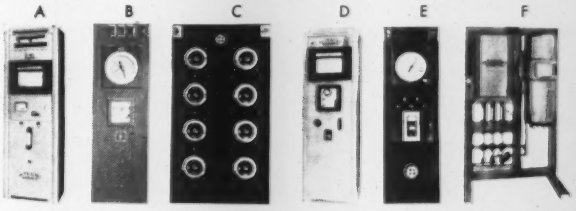
*Trademark

ACCURACY

Sustained accuracy of the M-S-A Billion-Aire is provided by use of a compensated detection system incorporating two similar ion chambers. One is supplied with reagent or converter. The other, with parallel flow of untreated sample gas. The response of the instrument is practically independent of flow rate.

THE MSA INSTRUMENT SPECIALIST

He has the facts. Over thirty years of delving and anticipation in the field of gas analysis have helped our company prepare this man. Ask him for specific information on the M-S-A Billion-Aire. And write us for helpful literature.



A. M-S-A® LIRA Infrared Analyzer
B. M-S-A® Inert Gas Analyzer
C. M-S-A® Combustible Gas Analyzer
D. M-S-A® Gas Thermatron
E. M-S-A® Oxygen Indicator
F. M-S-A® Water Vapor Recorder

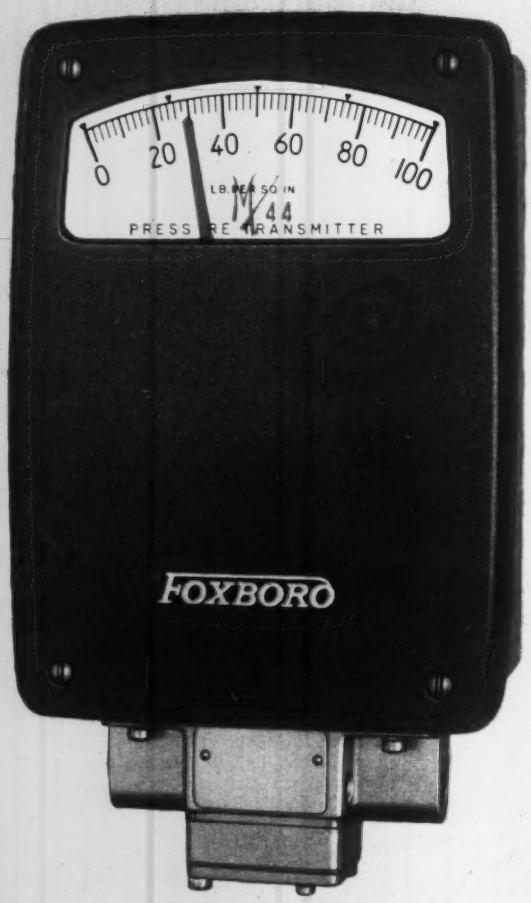
INSTRUMENT DIVISION • Mine Safety Appliances Company • Pittsburgh 8, Pennsylvania

MSA

For more information circle **26** on inquiry card.

read pressure up to 20 ft. away!

on the FOXBORO M/44 INDICATING PRESSURE TRANSMITTER



You can check pressure readings at a glance on the Foxboro Pneumatic Indicating Pressure Transmitter. Its open-face, horizontal, 4-inch indicator scale and eye-catching red pointer are clearly visible as far away as 20 feet.

But high readability is just part of the story. Actually, this instrument was engineered from the ground up. Makeshift arrangements have been eliminated, hung-on gauges are gone. Everything is included in one compact (5¾" x 8⅛"), ready-to-install instrument that weighs only eight pounds.

Because the indicating pointer is direct-connected to element and transmitter, calibration is easy . . . and you can re-zero the transmitter externally. All M/44 components are standard, performance-proved Foxboro parts. This makes it easier to stock and service.

A wide selection of interchangeable Foxboro pressure measuring elements gives the M/44 range limits of 0-30" water to 0-6000 psi. Elevated ranges are available, too.

Write for complete details. **The Foxboro Company, 464 Neponset Ave., Foxboro, Mass.**

FOXBORO
REG. U.S. PAT. OFF.

INSTRUMENTATION FOR INDUSTRY

For more information circle **27** on inquiry card.

New York Stock Exchange:

Continued from page 488

	HIGH	LOW	PRICE AS OF 3/16/59
Mallory	42	23 5/8	40 1/4
Minneapolis-Honeywell	126 1/2	76	121 1/2
Minnesota Mining & Mfg.	134 3/4	73 1/2	129
Motorola	86 3/4	35	85 1/4
National Acme	59 1/2	43 7/8	57
National Cash Register	86 1/4	50 1/2	72 3/4
North American Aviation	48 3/8	25 5/8	48
Northrop Aircraft	42 3/8	22 1/8	41
Otis Elevator	75 1/4	40 1/4	73 1/4
Philco Corp.	51 7/8	12 3/8	30
Radio Corp. of America	58 5/8	30 1/4	57 3/4
Raytheon Mfg.	70 1/8	21 1/2	66 3/8
Reliance Electric	50 5/8	31	48 1/2
Rheem Mfg.	24 1/8	10 1/2	22
Robertshaw-Fulton	45 1/4	22 1/4	42 7/8
Royal McBee	25 1/4	16	22 1/8
Sangamo Electric	49 1/4	25	43 3/4
Siegler Corp.	42	12 3/4	38 3/8
Sperry Rand	25 3/8	17 1/4	23 1/2
Square D	33 1/4	20 1/8	31
Standard Coil Products	21 3/4	6	19 3/8
Starrett (L.S.)	74 3/4	57	69
Stewart-Warner	46 3/4	29	45
Telautograph	13 1/4	3 3/4	12
Texas Instruments	88 3/8	26 3/4	84 1/4
Thompson-Ramo-Wooldridge	73	41 3/8	62 3/4
Tung-Sol Electric	54 1/4	23 1/4	51 5/8
Underwood Corp.	30 7/8	12 7/8	28 1/2
Union Carbide Corp.	133	83 7/8	129
United Shoe Machinery	51 1/8	32	50 3/4
Western Union	39 3/4	15	38 3/8
Westinghouse Air Brake	36 3/8	17 7/8	35 3/8
Westinghouse Electric	81	55 1/2	79 3/8
Worthington Corp.	80 1/4	45 1/4	78 1/2

Over-The-Counter

	QUOTATIONS AS OF 3/16/59 BID	ASKED
Aerovox Corp.	6 3/4	7 3/8
Aircraft Radio Corp.	33	34
Argus Corp.	41 1/2	42 1/2
Bitel-McCullough	36 1/4	37 1/2
Electronics Associates	47	48 1/2
Erie Resistor Corp.	9 3/4	10 5/8
Fisher Governor Company	18 1/2	19
Foxboro Company	51 1/2	53
G. M. Giannini	27 3/4	29
Industro Transistor	3 1/4	3 3/4
Liquidometer Corp.	8	8 3/4
W. L. Maxson	13 3/8	14
Penn Controls	20	-
Speer Carbon Inc.	31 1/2	-
Sprague Electric	42	44 1/4
Taylor Instruments	38 1/4	39 1/4
Telecomputing Corp.	11	12 1/8
Topp Industries	13	13 7/8
Varian Associates	45 3/4	46 3/4
Vitro Corp. of America	17 1/2	18

NO TEMPERATURE OVERSHOOT

WHEN SIMPLYTROL MINDS THE POT

time-proportioning controller has unique anticipating action

Low-cost Simplytrol gives you high-accuracy temperature control . . . effectively maintains temperature to within ± 1°F. of set point on most applications. An ingenious anticipating circuit eliminates overshoot difficulties by shutting off heat input at a time-proportioned interval before the set-point temperature level is attained.

Built around the well-proven A.P.I. meter-relay design, Simplytrol uses no amplifying circuits or vacuum tubes; it is exceptionally stable and reliable. The unit is available in thirty ranges from —400°F. to +3000°F., is packaged in a newly re-styled table-mounting case that converts in minutes to panel mounting.

SEND FOR DATA SHEET 9-B

api **ASSEMBLY PRODUCTS, INC.**

Chesterland 10, Ohio

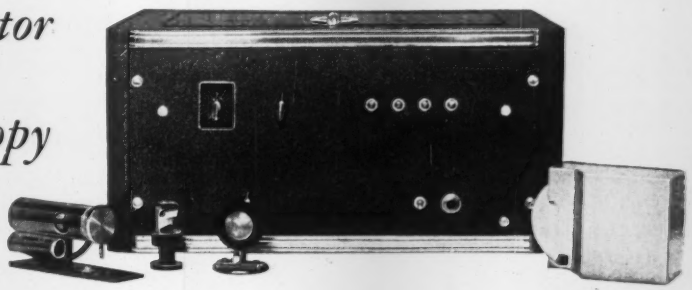
S.A.. 1913

For more information circle **28** on inquiry card.

A Superior Detector

for

Infra-Red Spectroscopy



GOLAY PNEUMATIC DETECTOR

Among the characteristics that render the Golay Detector superior to other types of detectors for use in infrared spectroscopy are:

1. **An effective sensitive area 3/32" in diameter.**
2. **Sensitivity of 6 x 10^{-11} watts RMSENI when used with "chopped beam" method and with recording time constant of 1.6 second.**
3. **Uniform sensitivity from the ultra-violet through the visible and the entire infra-red, and up to the micro-wave region.**
4. **Improved, drift-free, A.C. operated amplifier with step gain controls and four response periods.**

Write for EPLAB Bulletin No. 10

THE EPPLEY LABORATORY, INC.

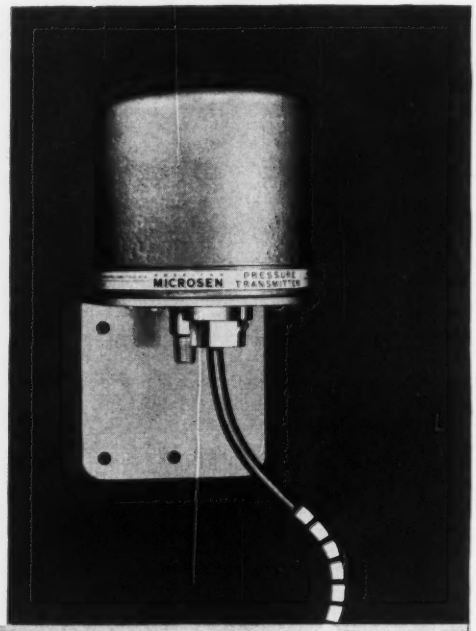
SCIENTIFIC INSTRUMENTS

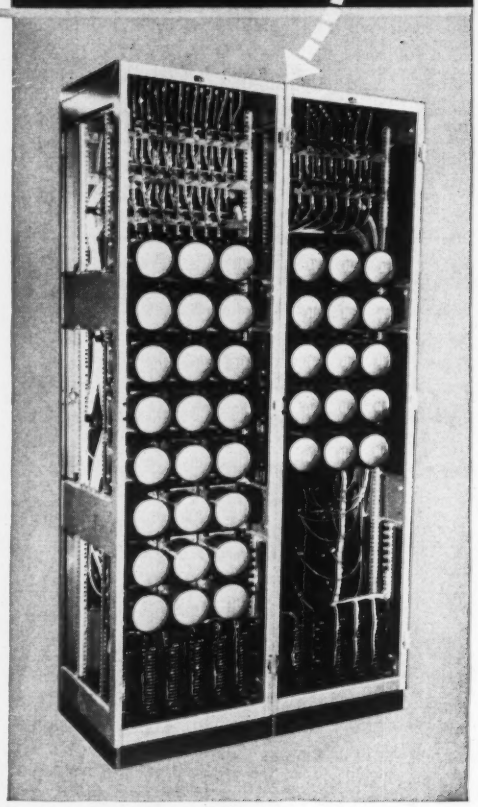
2 SHEFFIELD AVENUE, NEWPORT, RHODE ISLAND, U.S.A.

For more information circle **29** on inquiry card.

NOW... a compact ELECTRO-PNEUMATIC PRESSURE TRANSDUCER

for data reduction systems





The American-Microsen® Series 185 Pressure Transducer is designed to convert pressure signals to dc signals for use with data handling, telemetering or computer equipment. It can be supplied with input ranges from 0-15 psi up to 0-1000 psi; also 3-15 psi to transduce pneumatic signals.

The Series 185 Pressure Transducer converts pressure signals to 1.0 to 5.0 ma. dc which is readily accepted by data handling systems. Sensitivity of the unit is practically infinite. It has a repeatability of 0.3% of span; speed of response is 10 cps.

Use of the Microsen Balance enables the transducer to transmit signals instantaneously over long distances. An external power supply is employed which can be filtered to provide a high signal-to-noise ratio as required in high speed data handling equipment.

Housed in a dust and weatherproof case for universal mounting, the Series 185 Pressure Transducer can be installed on a vertical surface, pipe pedestal or meter piping. It is also readily adaptable to rack mounting as shown at the right. Get detailed information. *Write for Bulletin TP515.*

MAXWELL MANNING & MOORE INC. M&M TRADE MARK

MICROSEN ELECTRONIC CONTROLS

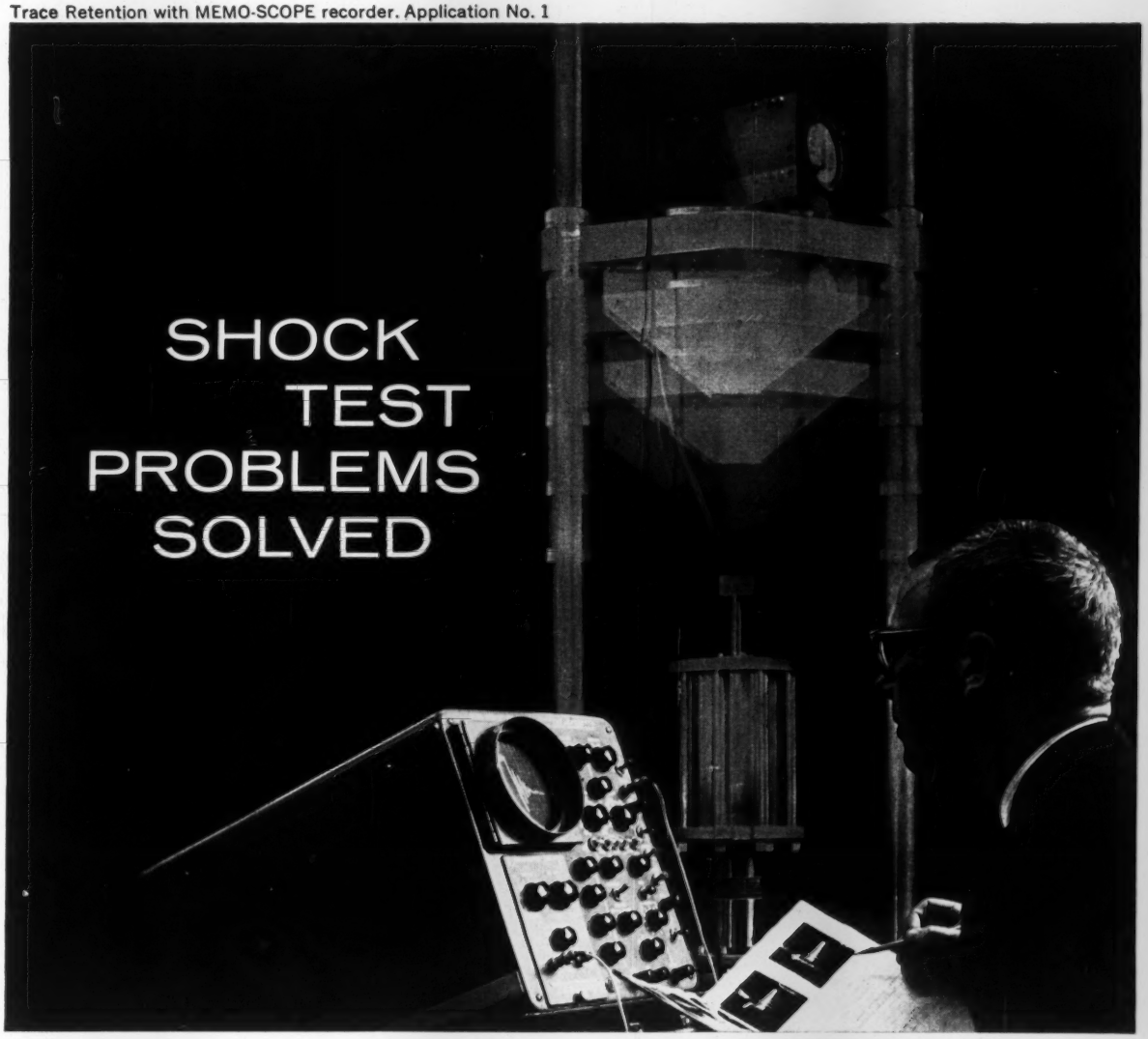
A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

For more information circle **30** on inquiry card.

Trace Retention with MEMO-SCOPE recorder. Application No. 1



Now with the Hughes MEMO-SCOPE® oscilloscopic recorder you can instantly freeze wave forms which record shock and other environmental tests. In association with the Hyge Shock Test Unit, manufactured by Consolidated Electrodynamics, you can produce predictable, repeatable acceleration shock thrusts. The information can be stored on the face of the MEMO-SCOPE recorder for hours – or even days if necessary – until intentionally erased. Successive wave forms may be written above, below or directly over the original information. This ability to freeze transients for study saves you time and money in transient analysis.

In addition to physical testing (shock, stress, and strain) the MEMO-SCOPE recorder makes it possible for you to solve problems associated with:

- *Ultrasonic flaw testing*
- *Drift measurements*
- *Ballistics, explosives research*
- *Switch, relay contact studies*
- *Transducer testing*
- *XY plotters*
- *Medical diagnosis problems*
- *Trouble shooting*

Many unique problems have been solved with the MEMO-SCOPE *recorder through trace retention. Refer your problems to us by writing: Hughes* MEMO-SCOPE *recorder, Hughes Products, International Airport Station, Los Angeles 45, California.*

SPECIFICATIONS:
Sweep Speed for Storage: 10 microseconds per division (0.33").
Frequency Response: DC to 250 KC down 3 db.
Sensitivity: 10 millivolts to 50 volts per division or with optional high sensitivity preamplifier 1 millivolt to 50 volts per division.

Creating a new world with ELECTRONICS

HUGHES PRODUCTS

© 1959 HUGHES AIRCRAFT COMPANY

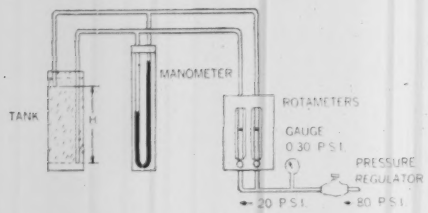
SEMICONDUCTOR DEVICES · STORAGE AND MICROWAVE TUBES · CRYSTAL FILTERS · OSCILLOSCOPES · RELAYS · SWITCHES · INDUSTRIAL CONTROL SYSTEMS

For more information circle **31** on inquiry card.

briefs

Manometers

Accuracy of a manometer depends on the use of an indicating fluid having certain clearly defined characteristics. For this reason, mercury and water, being readily obtainable and quite stable, have been recognized for years as standard.



TYPICAL DENSITY SYSTEM (CONSTANT PURGE)

To meet present day needs for extreme accuracy in broader application requirements, Dynametrics has made innumerable tests and is developing fluids with relatively uniform characteristics, in a wide range of specific gravities.

Manometer Applications . . . (1) Differential Gauge Pressure . . . (2) Flowmeter . . . (3) Domestic Gas Meters . . . (4) Tank Gauges . . . (5) Specific Gravity Indication . . . (6) Interface Identification . . (*From new 8-page Bulletin "Manometers—Theory and Application," Dynametrics Corp., Northwest Industrial Park, Burlington, Mass.*)

For this literature circle **161** on inquiry card.

Thermistor Thermometer Has High Accuracy

The Thermophil electronic thermometer consists of a small, light weight, battery-operated indicating instrument with one or more of the many types of interchangeable probes . . . The instrument is based on the change in electrical resistance of a special germanium alloy (thermistor) located in the tip of the probe. The resistance of this bead is 50,000 ohms at 20°C . . . Features are high accuracy and wide range, from −328° to +845°F. Accuracy for the instruments is as follows:

	Temperature span per scale range: 70°C to 126°F	20°C or 36°F or less
Readings between:		
−50°C to +50°C	0.7°C	0.14°C plus or minus
50°C to 100°C	1.0°C	0.2°C plus or minus
100°C to 200°C	1.5°C	0.3°C plus or minus . . .

(*From new Bulletin "Thermophil," Atkins Technical, Inc., Marion Bldg., Cleveland* 13, *Ohio.*)

For this literature circle **162** on inquiry card.

Digital Voltmeters in Automatic Systems

The design of NLS digital instruments enables them to operate a wide variety of data logging devices when data recorder connection is specified. Clary printer, tape punch or printer-punch combination can be operated without auxiliary equipment, as can certain card punches . . .

The addition of an input scanner and data recorder to a digital instrument provides a complete automatic data logging system which sequentially samples up to 1,000 input channels and digitalizes and records each input signal selected . . .

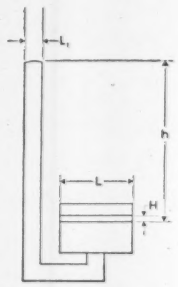
NLS illuminated digital readouts display the same data as does the digital measuring instrument they connect to. They are available in ½ or 1 inch numerals in standard modules of one to six windows or custom modules up to twelve windows . . . (*From new 6-page folder, Non-Linear Systems, Inc., Del Mar, Calif.*)

For this literature circle **163** on inquiry card.

Well-type Manometers

The well type form of Manometer is subject to the following errors: scale, temperature, compressibility, capillarity and gravitational. In the new Trimount Series 20 instruments, every one of these sources of error has been eliminated.

Considering the scale first, Trimount uses a scale that is based on standard unit of length. The scale is not foreshortened to compensate for well drop



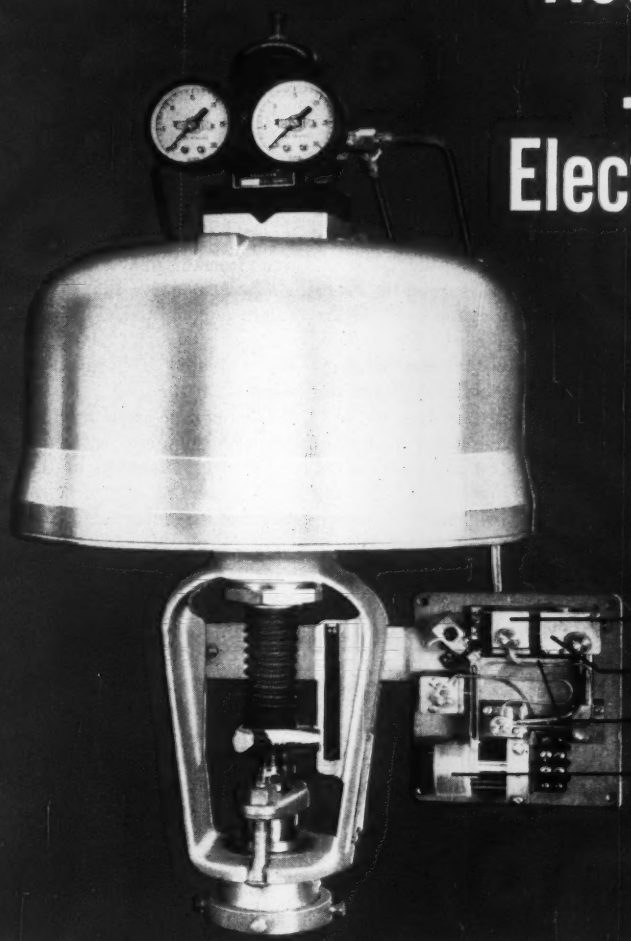
nor expanded to compensate for temperature. It is a true linear scale that can be measured at a specified temperature and checked, providing a means of checking the instrument.

The well drop has troubled so many engineers and technicians. Stated in simple terms, the sum total of errors—temperature, gravitational, etc. is made equal to the well drop.

As a matter of practice and convenience the area of the well is deliberately made oversize after which the area is corrected by inserting a plug of known diameters. This provides the correction for local gravity, temperature, and well drop . . . (*From new 12-page Catalog T* 1771, *Trimount Instrument Co., 3119 West Lake St., Chicago* 12, *Ill.*)

For this literature circle **164** on inquiry card.

Now! From Annin ...the Finest in Electro-Pneumatic Actuators



Annin's Model 30,000 transducer, coupled with the Annin Domotor, gives you greater range of adjustment, unequalled stability, and exceptional dynamic characteristics

The Model 30,000 has been developed to provide process engineers with a practical transducing element for converting a small electrical signal to an accurate and stable pneumatic output pressure. It embodies only four basic sub-assemblies, which minimize motion and wear, simplify adjustment and installation. The Model 30,000 features full-scale zero adjustment and a wide range of span settings for split range and sequencing applications. Absence of complex components, together with minimum installation,contribute to low maintenance. Linearity and accuracy reach a new high in electro-pneumatic transducing with the Model 30,000. *Technical data on request*

Annin VALVES

Send for your copy of Annin's new Catalog 1500-D

Annin VALVES

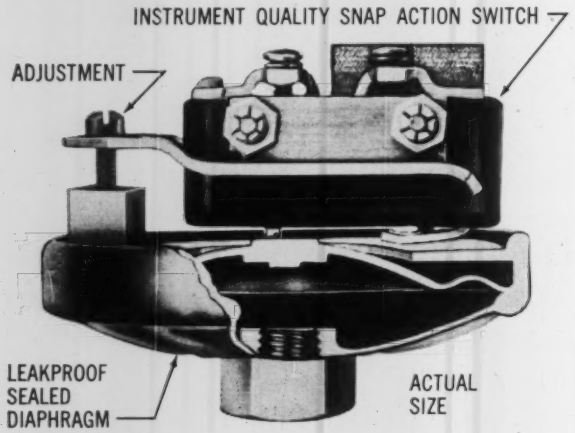
THE ANNIN COMPANY Division of The Annin Corporation
1040 S. Vail Ave., Montebello, California

For more information circle **32** on inquiry card.

NEW PRESSURE SWITCH FOR THE O.E.M.

This *stripped* switch is designed specifically for the Original Equipment Manufacturers who enclose the various controls in a common cabinet. This new pressure and vacuum switch model 402, incorporates the same dependable accuracy and other operating features of the proven *housed* model 420.

Cost and price have been cut by eliminating the housing.



HERE'S THE SIMPLEST DIAPHRAGM PRESSURE SWITCH

WE BUILD IN	WE DON'T USE
EXTREME ACCURACY and DEPENDABILITY maintained during operating life due to direct acting design	LINKAGE and BEARINGS which, as they wear, make the setting of the pressure switch drift.
EFFICIENT OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch that uses liquid switching elements	LIQUID SWITCHING ELEMENTS which make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	ACCORDION BELLOWS which make the pressure switch sensitive to vibration.

Ask for new catalog '59-'60

PRESSURE SWITCH DIVISION

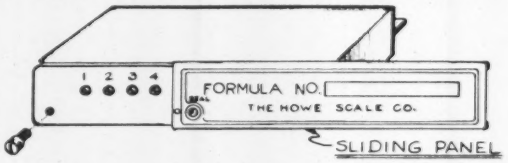
Barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

For more information circle **33** on inquiry card.

Automatic Batch Weighing

Batchplugs are formula control devices . . . for use with Batchmaster equipment. They provide complete control for up to ten ingredients per formula—on as many as three separate scales . . . Each formula has its own pre-set and sealed Batchplug which,



when plugged into a Batchmaster panel, will control the automatic batching operations for that particular formula . . . All formulation is prepared in advance —ready for instant use . . .

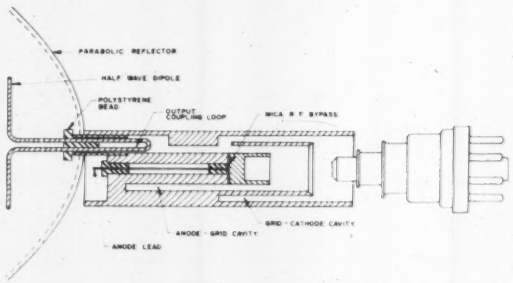
The Batchplug to be calibrated is plugged-in and the Batchmaster test-switch is turned on . . . The adjustment screw for the number one ingredient on the Batchplug is then rotated to the point at which the test light comes on . . . Upon completion of the first ingredient adjustment, a push of the test button will ready the equipment for a similar adjustment of the next ingredient . . . (*From new 4-page Bulletin EP-SD-29, Howe Scale Co., Rutland, Vt.*)

For this literautre circle **165** on inquiry card.

Microwave Optics

Microwaves have, for man, a unique place in the electromagnetic spectrum. They are no more than the length of a man's hand and can be measured on an ordinary meter stick. Since they are identical in nature with the other electromagnetic radiations, a study of microwaves may be introductory to the study of x-rays, visible light and radio waves.

The basic equipment for the study of microwaves is a transmitter for producing the radiation and a receiver for exploring the field . . .



The one-piece transmitter consists of power supply, oscillator and antenna. The oscillator, shown diagrammatically in Fig. 1, consists of two resonant cavities built concentrically to fit the General Electric 2C40A disc-seal triode tube, commonly known as the "lighthouse tube." A wire loop of a half-turn couples the inner cavity directly to the half-wave antenna at the focus of the parabolic deflector. The paraboloid is a quarter-wave in focal length . . . (*From new 28-page Booklet MWO, "Suggested Experiments in Microwave Optics," Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.*)

For this literature circle **166** on inquiry card.

CLARE Lowers Prices

Type HG

Type HGP

Type HGS

Type HG2

Type HG4

on all Mercury-wetted contact relays

Reductions range from 7½% to 10%

When prices for just about everything are continuing to rise, and all thinking men are concerned over the danger of inflation, it is important news when a manufacturer makes a significant price reduction.

Increased production resulting from the wide acceptance of Clare Mercury-Wetted Contact Relays, together with improvements in skill and in manufacturing equipment and methods, make it possible for Clare to reduce prices for these superior relays in spite of rising labor and material costs.

A price reduction ranging from 7½% to 10% will be applied to all orders placed after March 31, 1959, for Clare Mercury-Wetted Contact Relays—Types HG, HGP and HGS. The reduction will also affect multi-element relays such as HG2, HG3, HG4, etc.

These lower prices for relays whose life is measured in *billions of maintenance-free operations* will be exciting news to all designers of continuous-duty, high-speed switching devices and systems.

Write or Wire: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 2700 Jane Street, Toronto 15. Cable Address: CLARELAY.

CLARE RELAYS

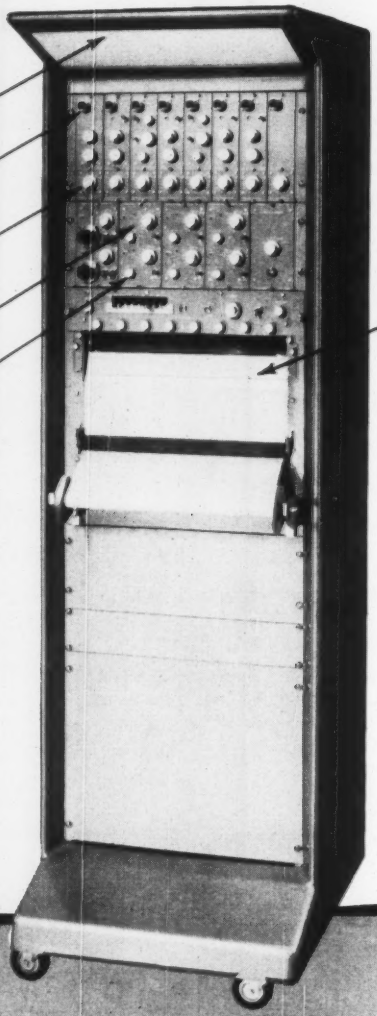
FIRST in the industrial field

For more information circle **34** on inquiry card.

OFFNER
ALL TRANSISTOR

TYPE R DYNOGRAPH

the most versatile . . . most sensitive direct writing unit available



Illuminated canopy

Type 9800 series input couplers provide all input, control and balance functions. Input available both front and rear.

Type 481 Preamplifier provides sensitivities from one microvolt to 5 volts per mm.

Type 482 power amplifiers—may be used without preamplifiers for up to 10 mv/cm sensitivity

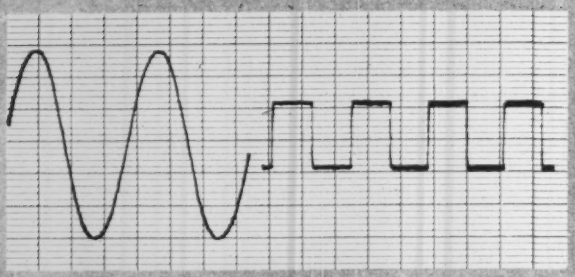
Zero suppression control

504-A paper drive—speeds from 1 to 250 mm/sec. Electrical speed shift 1 to 250 mm per minute available. Zero weave high precision drive, 850 ft. capacity (heat or electric) 1500 ft. (ink). Front loading, with full unobstructed record visible from front.

Combining all these features...

- *stable d-c sensitivity of one microvolt per mm*
- *true differential input*
- *high input impedance*
- *response to beyond 150 cps.*
- *reluctance, differential transformer, strain gage with a-c or d-c excitation, thermocouples, etc., used with all preamplifiers*
- *deflection time less than 1.5 milliseconds (2.5 ms with preamplifiers)*
- *fixed precision calibration*
- *instant warm-up*
- *precision source for d-c and 400 cycle excitation, self-contained*
- *zero suppression, twenty times full scale, both directions*

FULL SCALE, UNRETOUCHED CHARTS PRODUCED ON THE TYPE R DYNOGRAPH



EXTREME SENSITIVITY

10 Microvolt RMS Sine Wave **Ten Microvolt D-C Square Wave**

Four recording media. Heat or electric rectilinear—ink or electric curvilinear. Readily convertible.

All these features . . . plus 8 channels in only 35" of rack space. Whatever your application for direct writing records . . . you should investigate the ability of the Offner Type R Dynograph to do the job *better* and more *simply*. Using transistor circuits* developed and tested for over three years in thousands of channels of Offner equipment, the Type R Dynograph has already proved its superiority in practically every respect to *any other* direct writing oscillograph. Write on your company letterhead for literature giving details and specifications.

**Patents granted and pending*

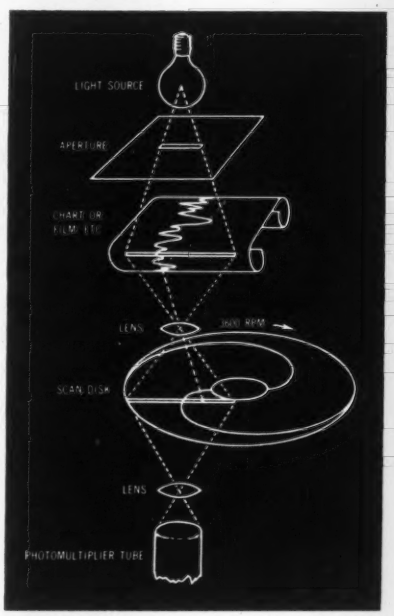
OFFNER ELECTRONICS INC.

3910 River Road, Schiller Park, Ill.
(Suburb of Chicago)

For more information circle 35 on inquiry card.

Automatic Chart Reader

The Basic Reader consists of an optical projection system, a scanning system, and electronic circuitry. It is located so that a thin strip of light, focused on the chart at right angles to the long axis of the chart, reflects a narrowing cross-sectional image of the chart onto a rotating scan disk. The dark trace of



the chart does not reflect light; however, the white paper background on either side of the trace does reflect. Therefore, the strip of light imaged on the scan disk appears to be broken by a dark "spot." When the drive is turned on and the chart is set into motion, this spot undulates back and forth across the surface of the disk exactly as the trace undulates on the chart . . . (*From new 4-page bulletin, The Geotechnical Corp., 3712 Haggar Drive, Dallas, Texas.*)

For this literature circle **167** on inquiry card.

Digital Systems

Typical Cubic Digital System measures and records any combination of 100 ac and dc voltages automatically without human monitoring . . . Master Scanner sequences the selection of multiple inputs by the auxiliary scanners. The selected channel appears on a readout and is available to the printer . . . Auxiliary Scanner accepts 100 inputs each and distributes them to as many as 5 outputs selected by the Master Scanner . . . (*From new 4-page bulletin, Cubic Corp., 5575 Kearny Villa Rd., San Diego 11, Calif.*)

For this literature circle **168** on inquiry card.

REMOTE BULB, INDICATING TEMPERATURE CONTROL E32N

Type **E32N**

Featuring Control Point Accuracy Equivalent to Individually Calibrated Instruments

The **UNITED ELECTRIC** Type E32N Temperature Control is a uniquely designed instrument that is used to control and indicate temperatures of gases, liquids or hot plates over wide ranges. This unit contains a 12-inch scale for easily read visual indications. It is possible to replace the thermal unit in the field without any loss of calibration accuracy.

Temperature Ranges	—150°F. to 150°F., 70°F. to 370°F., 100°F. to 650°F. Read temperature on continuous, 12-inch indicating scale that rotates against a fixed index pointer in a vertical and centered location.
Switch Ratings	Up to 15 amps. at 115 or 230 volts A.C. 20 amp. A.C. or D.C. switches also available.
Switch Types	N.O., N.C., or Double Throw — no neutral position.
On-Off Differential	Approximately 1.0°F. or 2.0°F. dependent on model.
Adjustment	Calibrated dial rotated against a fixed index.
Calibration	Calibrating mechanism permits precise matching of scale to individual tolerance errors of thermal assemblies.
Compensation	Automatic compensation for ambient temperatures.

SEND FOR NEW Catalog 200 for full information on the E32N and other remote bulb temperature controls.

UE® **United Electric Controls**
COMPANY
82 SCHOOL STREET, WATERTOWN, MASS

For more information circle **36** on inquiry card.

YOUR *FISHER/MAN* STANDS BEHIND THIS

FOR Inherent Accuracy–Power–Speed–and Stability

FISHER TYPE 470 P.O.P.

Delivers same power in either direction at any point of the stroke.

No air set required—utilizes clean, noncorrosive air or gas up to 150 psi.

Adaptable to virtually all types of valve bodies including Butterfly valves.

Easily reversible actuator can be changed in the field.

This small, compact, pneumatically operated piston is available in five sizes with yoke sizes to fit any of the Fisher valve bodies including Butterfly valves. P.O.P. acts with high speed. For example, the 8½-inch size gives you 1.5 inches per second stroking speed. Write Fisher Governor for Bulletin E-59.

Type 470 P.O.P. With Fisher Bodies				
Cylinder Size, Inches	Yoke Boss Size, Inches	Valve Body Size, Inches	Stem Size, Inches	Allowable Stem Force, Lbs.
4¾	2⅛	½—1½	⅜	1,500
	2 13/16	2—4	½	*
	3 5/16	5—8	¾	*
6⅛	2 13/16	2—4	½	2,500
	3 5/16	5—8	¾	*
8½	3 5/16	5—8	¾	5,000
10¾	5	10—16	1	8,000
13	5	10—16	1¼	12,000

*Limitation with these stems is dependent upon the maximum force available from each cylinder.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY . . .

FISHER GOVERNOR COMPANY

Coraopolis, Pa. / Woodstock, Ontario / London, England

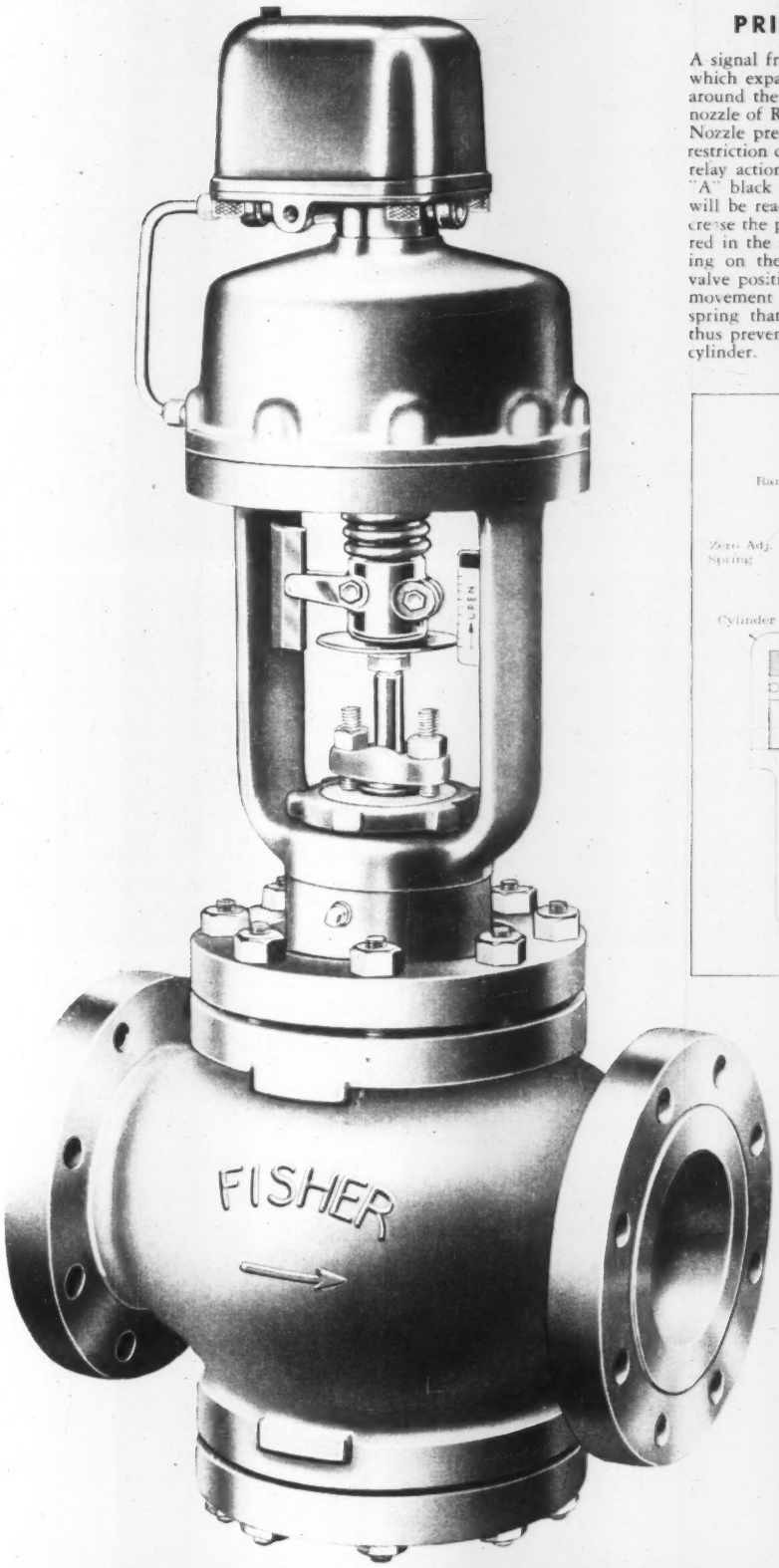
Main Office and Plant: MARSHALLTOWN, IOWA

FISHER® Controls

SINCE 1880

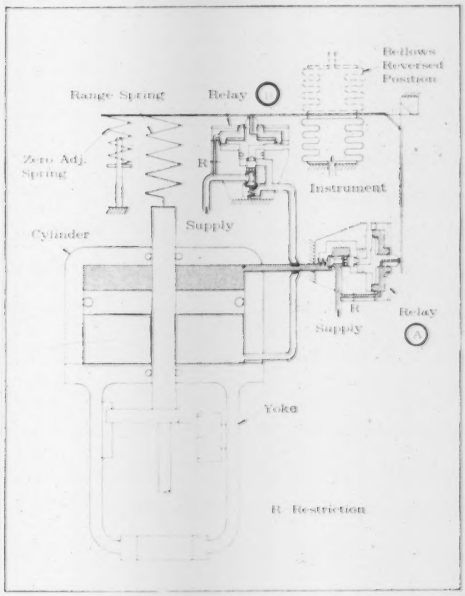
For more information circle 37 on inquiry card.

PNEUMATICALLY OPERATED PISTON . . .



PRINCIPLE OF OPERATION

A signal from the controller is received by the bellows which expand to move the beam. The beam will pivot around the fixed point and simultaneously uncover the nozzle of Relay "B" and cover the nozzle of Relay "A". Nozzle pressure will increase in Relay "A" due to the restriction created by the beam over the nozzle. Through relay action, the air pressure to the top of the piston, "A" black in the sketch, will be increased. Relay "B" will be reacting to the change in beam position to decrease the pressure to the under side of the piston, "B", red in the sketch. Due to the unbalanced pressures acting on the piston, it will move down, changing the valve position as dictated by the controller. The piston movement is fed back to the beam by means of a range spring that is connected to the piston rod extension, thus preventing any further build-up of pressure in the cylinder.



Exterior view of high pressure actuator. Type 470 mounted on a Design "A" body.

For more information circle **37** on inquiry card.

In the Final Control Element . . .

ACCURACY AND DEPENDABILITY ARE KEY QUALITIES

That's Why So Many Process Plants Standardize on Masoneilan Control Valves

Many process control systems — in chemical, paper, petroleum, petrochemical, textile and other plants — use Masoneilan Control Valves exclusively because experience has proved that Masoneilan valves are accurate and dependable. And because they give this top performance over long periods, they are most economical.

The wide variety of applications pictured here are in one modern petroleum refinery which uses Masoneilan valves. There are Masoneilan types for practically all control systems in all other processing plants, too. If you are concerned with the selection of control valves, it will pay you to consider Masoneilan.

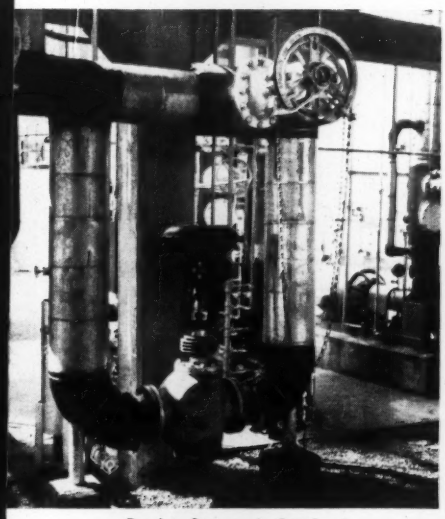
Complete details on control valves for every process use are yours for the asking. Write for catalog.

MASON-NEILAN

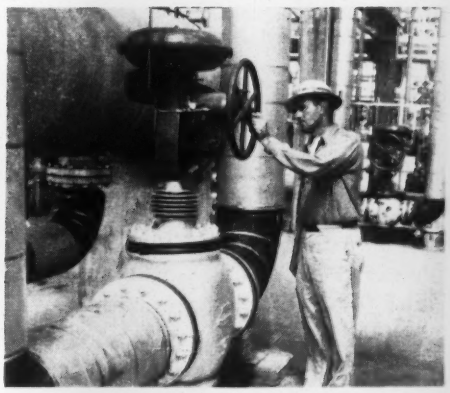
A Division of Worthington Corporation

55 NAHATAN STREET, NORWOOD, MASSACHUSETTS

District offices or Distributors in principal cities in U.S.
In Canada: Mason-Neilan, Division of Worthington (Canada), Ltd.

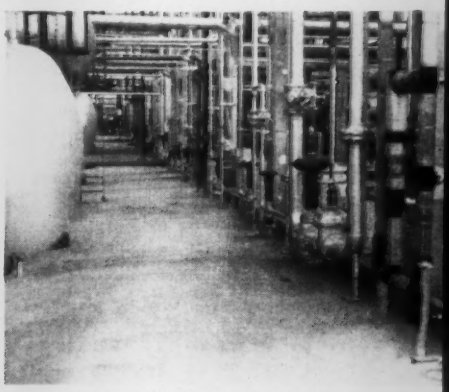


Feed to Storage in Cat Cracker



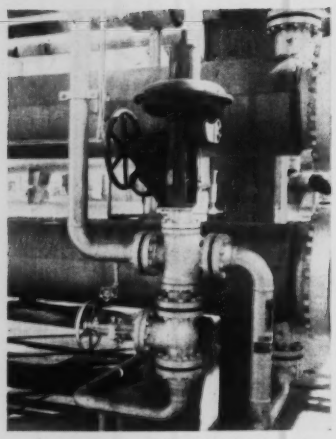
Effluent Control in Cat Cracker

For more information circle **38** on inquiry card.

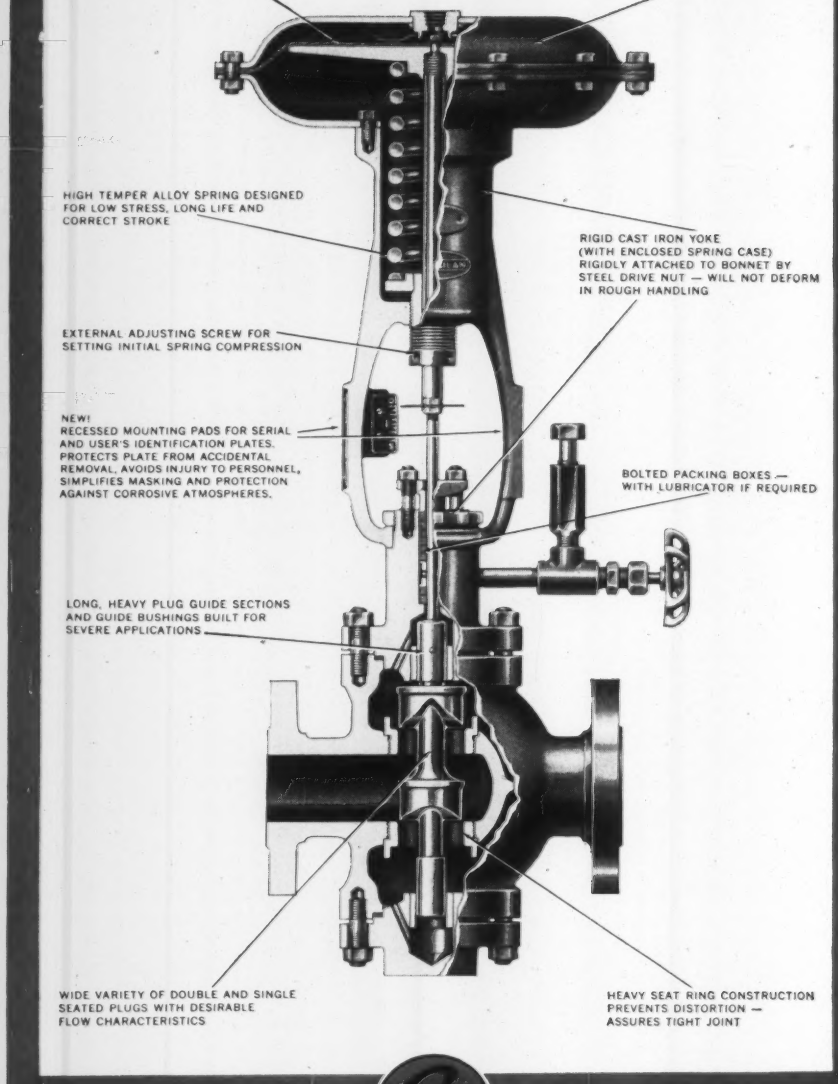


View of Cat Reformer using Many M-N Valves

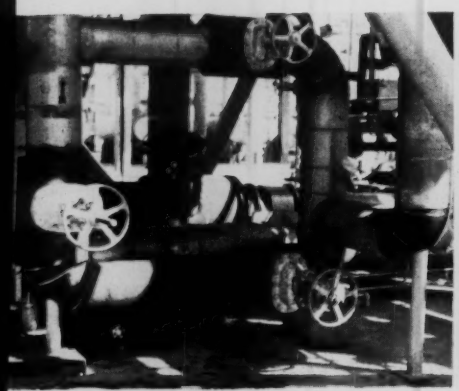
Crude Charge to Furnace



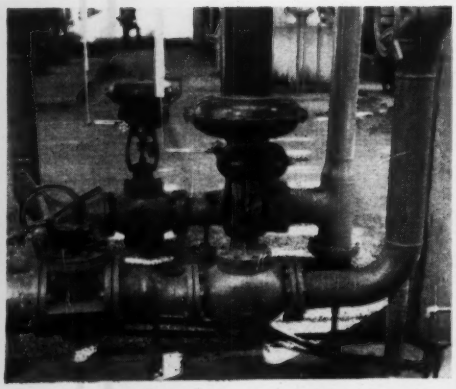
Reactor Effluent Flash Drum Control


MOLDED NEOPRENE DIAPHRAGMS WITH LARGE EFFECTIVE AREAS FOR MAXIMUM POWER AND LONG STROKE
LARGE STEEL DIAPHRAGM CASES TREATED TO RESIST CORROSION
HIGH TEMPER ALLOY SPRING DESIGNED FOR LOW STRESS, LONG LIFE AND CORRECT STROKE
RIGID CAST IRON YOKE (WITH ENCLOSED SPRING CASE) RIGIDLY ATTACHED TO BONNET BY STEEL DRIVE NUT — WILL NOT DEFORM IN ROUGH HANDLING
EXTERNAL ADJUSTING SCREW FOR SETTING INITIAL SPRING COMPRESSION
NEW! RECESSED MOUNTING PADS FOR SERIAL AND USER'S IDENTIFICATION PLATES. PROTECTS PLATE FROM ACCIDENTAL REMOVAL, AVOIDS INJURY TO PERSONNEL, SIMPLIFIES MASKING AND PROTECTION AGAINST CORROSIVE ATMOSPHERES.
BOLTED PACKING BOXES — WITH LUBRICATOR IF REQUIRED
LONG, HEAVY PLUG GUIDE SECTIONS AND GUIDE BUSHINGS BUILT FOR SEVERE APPLICATIONS
WIDE VARIETY OF DOUBLE AND SINGLE SEATED PLUGS WITH DESIRABLE FLOW CHARACTERISTICS
HEAVY SEAT RING CONSTRUCTION PREVENTS DISTORTION — ASSURES TIGHT JOINT

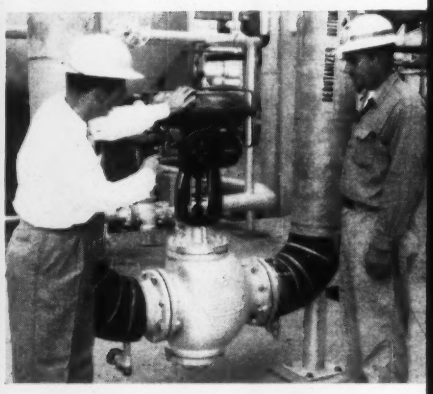
A HIGH Quality Coefficient PRODUCT



Cat-Cracker Feed Control



Gas to Fuel Drum and Flare Drum



Debutanizer Bottoms Control

For more information circle **38** on inquiry card.

In the Final Control Element . . .

ACCURACY AND DEPENDABILITY ARE KEY QUALITIES

That's Why So Many Process Plants Standardize on Masoneilan Control Valves

Many process control systems — in chemical, paper, petroleum, petrochemical, textile and other plants — use Masoneilan Control Valves exclusively because experience has proved that Masoneilan valves are accurate and dependable. And because they give this top performance over long periods, they are most economical.

The wide variety of applications pictured here are in one modern petroleum refinery which uses Masoneilan valves. There are Masoneilan types for practically all control systems in all other processing plants, too. If you are concerned with the selection of control valves, it will pay you to consider Masoneilan.

Complete details on control valves for every process use are yours for the asking. Write for catalog.

MASON-NEILAN

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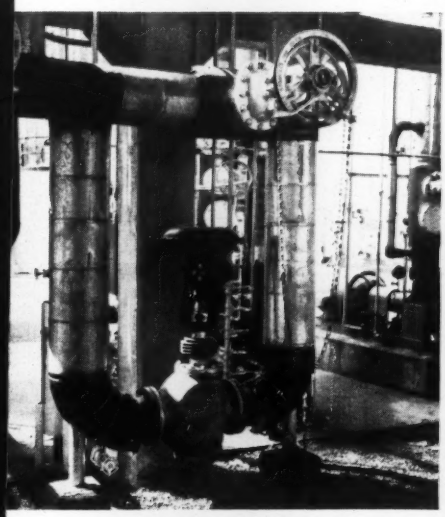
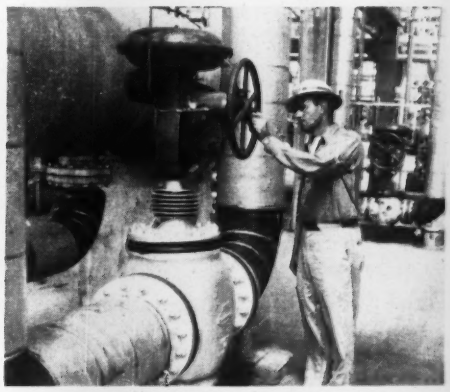
55 NAHATAN STREET, NORWOOD, MASSACHUSETTS

District offices or Distributors in principal cities in U.S.
In Canada: Mason-Neilan, Division of Worthington (Canada), Ltd.

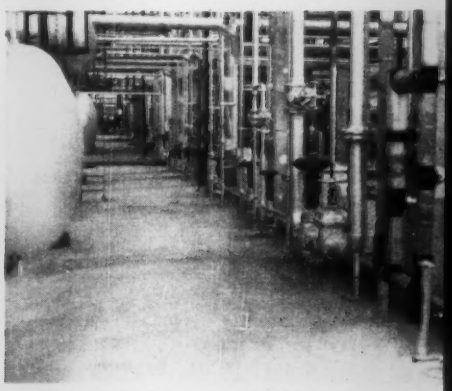


Feed to Storage in Cat Cracker



Effluent Control in Cat Cracker

For more information circle **38** on inquiry card.



View of Cat Reformer using Many M-N Valves

Synchro-Start AUTOMATIC ENGINE CONTROLS

SPEED SENSITIVE SWITCHES

Overspeed and Underspeed

FULL AUTOMATIC CONTROLS

Starting, stopping and safety protection

D. C. SOLENOIDS

Heavy duty

SAFETY ALARM SETS

Visual and audible alarms

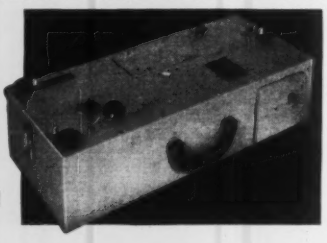
To furnish you with the control to fit your needs, send full engine data and installation specifications.

SYNCHRO-START PRODUCTS, INC.
Since 1932
8131 NORTH RIDGEWAY AVENUE • SKOKIE, ILLINOIS

For more information circle **39** on inquiry card.

PORTABLE... ACCURATE... EASY TO OPERATE...

Sprengnether's Blast and Vibration Seismograph



Ideal for recording all types of vibrations caused by blasting, pile driving, heavy industrial machinery and other sources of strong motion vibrations.

Portability (38 lbs.—25 x 10 x 8 in.) Unit is self contained and free from external power source.

Extremely Accurate To guard against error, each instrument is tested and calibration data furnished. Frequency response, 3 to 200 cycles per second. Timing lines are across record at intervals of 0.02 seconds with accuracy of 0.1%.

Easy to Operate: All controls are easily accessible. Instrument can be set up, leveled and made ready to operate within minutes.

Seismometer System: A mechanical, optical seismometer employing three independent pendulum systems with magnetic damping. System is contained within unit, hence, no need for external geophones.

Recording System: Photographic recording of all three components appearing on 2¾ inch wide paper. Cartridge type cameras are replaceable and can be pre-loaded to facilitate in the field camera replacement.

OTHER SPECIFICATIONS

Natural Period (All Components)	0.75 sec.
Damping (Fraction of Critical)	.55
Static Magnification	*

*May be specified by purchaser from 50 to 200. Two ranges in one instrument available.

Write today for complete information.

Internationally Known Mfrs. of Seismological, Geophysical Instruments.

W. F. SPRENGNETHER INSTRUMENT CO., INC.
4567 SWAN AVENUE • ST. LOUIS 10, MO.

For more information circle **40** on inquiry card.

Bearing Lubrication

Lubrication is obtained by the presence of oil or other substance between two surfaces in contact and in motion relative to one another. Lubrication of bearings may accomplish one or several purposes. It is used to reduce friction and wear . . . In addition to this, lubrication also cools the bearing by carrying away heat generated by friction . . . Petroleum or mineral oils are used for lubrication rather than animal or vegetable oils. Animal and vegetable oils are not chemically stable and tend to form gums . . .

Basically, grease is a combination of an oil and thickening agent. The thickening agent is usually a metallic soap such as calcium, sodium or lithium . . .

The American Petroleum Institute has set up a simplified gravity system known as the API Gravity, and the units are called Degrees API. The API scale covers specific gravities from 1.076 to 0.6112 and the scale runs in the opposite direction to that of specific gravity. The formula for the relationship is: Degrees API =

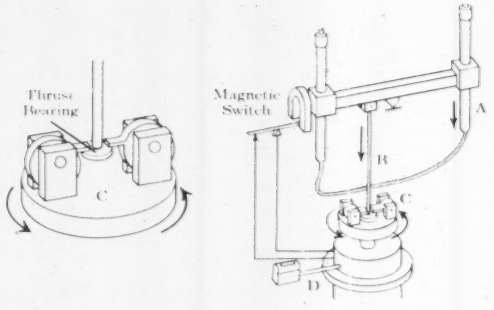
141.5/(specific gravity of oil at 60°F) — 131.5

(From new 28-page manual Reprint 5810, containing specifications of more than 60 oils, greases, and silicones: Miniature Precision Bearings, Inc., Precision Park, Keene N. H.)

For this literature circle **169** on inquiry card.

Centrimax Flowmeter

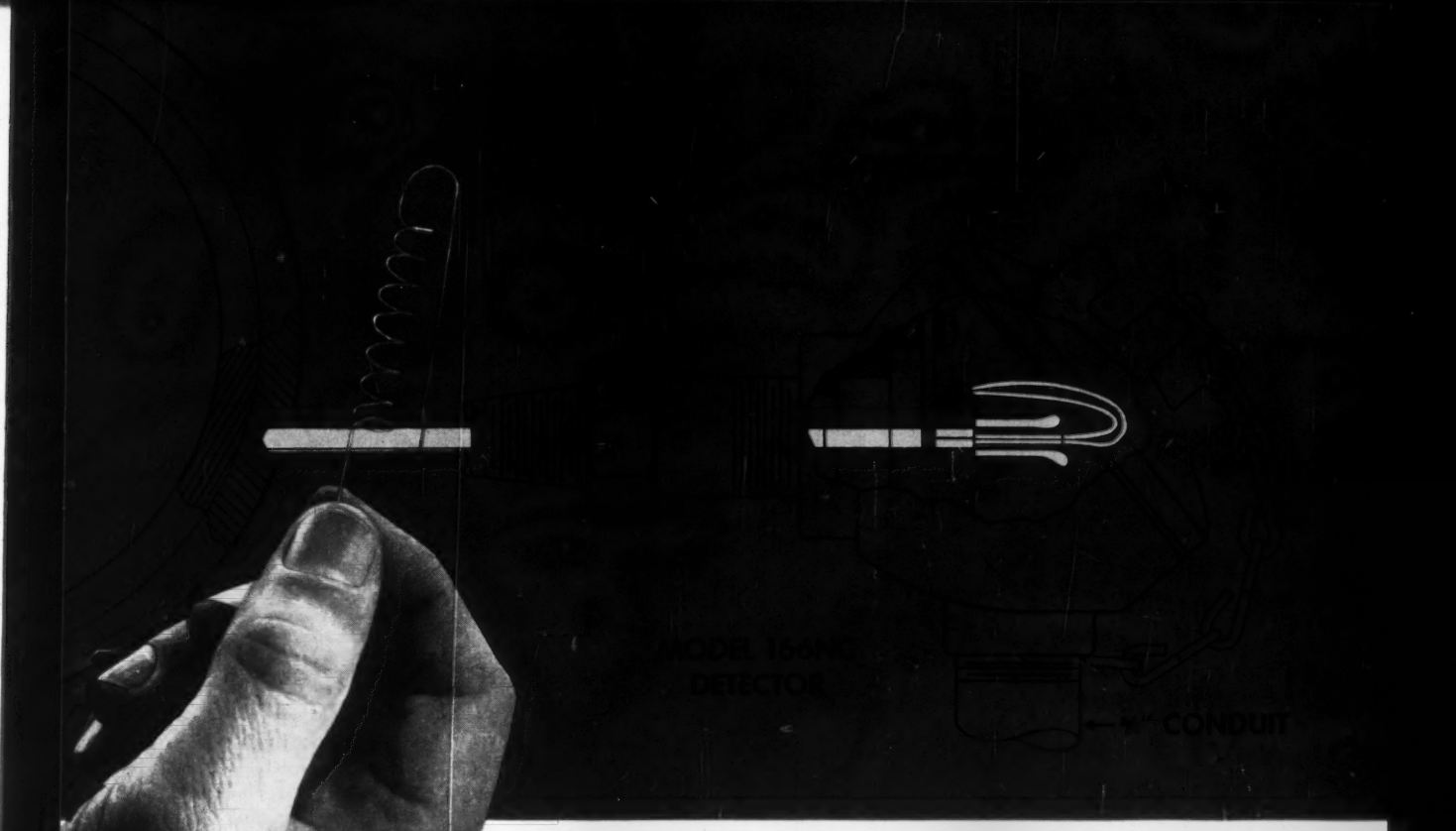
For integrated measurements, Centrimax employs the null-balance principle through use of a force balance. One force is the pressure differential from the primary element (orifice, Venturi tube, flow nozzle, or scroll case taps) which tends to unbalance



the tilting manometer mounted on the balance beam. The second is the centrifugal force developed by the rotating neutral flyball governor which opposes the unbalance. Flyball speed, regulated to maintain balance, is controlled by a magnetically operated switch actuated by the balance beam.

Since pressure differential is proportional to the square of the rate of flow, and centrifugal force similarly is proportional to the square of flyball speed, the square relationships balance out, leaving

Continued on page 506



THOMAS A.

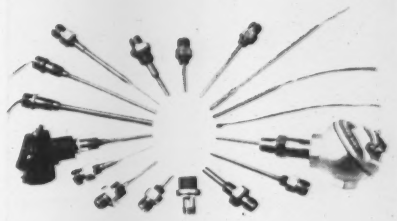
EDISON

resistance temperature detectors

STABLE · ACCURATE · FAST · SENSITIVE · RUGGED

Here's why they give you economical, long-life performance:

- **Simple operation.** The Edison Resistance Temperature Detectors consist essentially of a piece of high-resistance wire. When variations in the temperature of the measured medium cause a change in the resistance of the wire, enough power is developed to operate an indicator or relay and no amplification is required.
- **High-stability eliminates periodic calibration.** Because resistance wire is made from high-purity nickel and platinum. These metals are not subject to the contaminating effects of adverse atmospheres. As a result, there is no need for periodic recalibration.
- **Accurate.** As evidence of the unmatched accuracy of the Resistance Temperature Detector, the U. S. Bureau of Standards uses a platinum wire detector for measuring temperatures between minus 300°F and plus 1165°F. Standard Edison detectors are available with accuracy of 0.5%.
- **Rugged.** Edison detectors are designed to withstand the abuse, shock and vibration of industrial applications where other detectors can not survive. Typical of the tough jobs being handled by Edison detectors are sensing applications on the bearings of ore crushers, heavy conveyors, pulverizers and both turbo-jet and reciprocating engine aircraft.
- **For additional information** write for bulletin RTD #3047.



Edison Detectors are available for a wide range of applications and almost any type of service. They are compact, corrosion and vibration resistant.

McGRAW EDISON

Thomas A. Edison Industries

INSTRUMENT DIVISION

24 LAKESIDE AVENUE, WEST ORANGE, N. J.

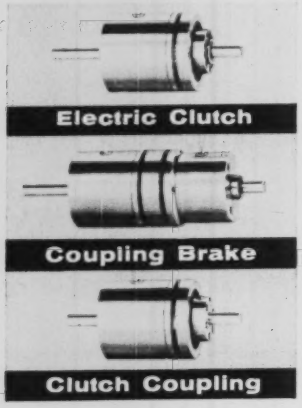
EDISON ENGINEERING OFFICES ARE LOCATED IN: CHICAGO · DALLAS · DAYTON · LOS ANGELES

For more information circle **41** on inquire card.

Compact – Quiet – Swift

Simplatrol

FIXED FIELD ELECTRIC CLUTCHES



Three styles from 7/8" to 3 1/8" Torque output from 10 oz. inches to 100 lb. inches.

In Miniature & Small Sizes

Introduced only a few short months ago, Simplatrol Fixed Field Electric Clutches have found popular application wherever space is tight, noise is objectionable and performance requirements are rigid.

PATENTED DIAPHRAGM ACTION Makes the Difference

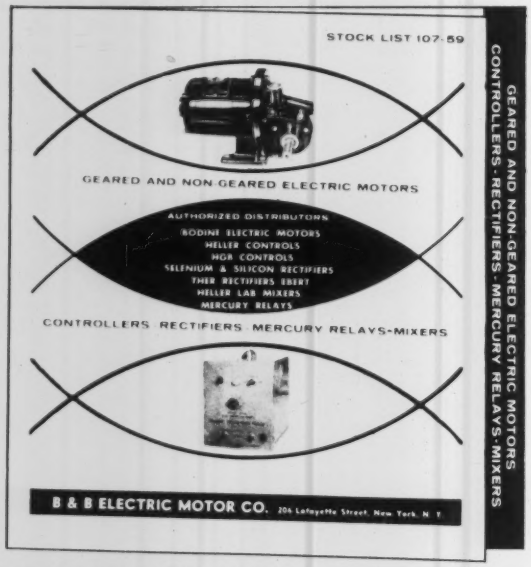
No other electric clutch and brake can duplicate the patented Simplatrol diaphragm . . . the *only* moving part in Simplatrol Fixed Field Clutches. Here is a proved advantage . . . offering an absolute minimum of maintenance.

Ask for Simplatrol Fixed Field Literature

Simplatrol *products corp.*
24-8 SALISBURY ST., WORCESTER, MASS.
Representation in Key Industrial Areas

404-8

For more information circle **42** on inquiry card.


STOCK LIST 107-59
GEARED AND NON-GEARED ELECTRIC MOTORS
AUTHORIZED DISTRIBUTORS
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HELLER CONTROLS
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SELENIUM & SILICON RECTIFIERS
THER RECTIFIERS EBERT
HELLER LAB MIXERS
MERCURY RELAYS
CONTROLLERS RECTIFIERS MERCURY RELAYS-MIXERS
B & B ELECTRIC MOTOR CO. 206 Lafayette Street, New York, N. Y.
GEARED AND NON-GEARED ELECTRIC MOTORS CONTROLLERS-RECTIFIERS-MERCURY RELAYS-MIXERS

INSIDE THIS FOLDER you'll find hundreds of listings of geared and non-geared electric motors — complete with prices and all available for immediate delivery. HP from 1/2000 — Speeds from .65 RPM. Also contained in easy to find form are pages on Heller Controls and Lab Mixers, HGB Controls — Selenium and Silicon Rectifiers — Ebert Mercury Relays — Ther Rectifiers — all completely described and priced for off the shelf delivery. For your FREE COPY just off the press write today. **B & B Electric Motor Company, 206 Lafayette St., New York, N. Y.**

For more information circle **43** on inquiry card.

BRIEFS—CONTINUED

flyball speed directly proportional to flow. To integrate flow, a simple revolution counter is geared to the flyball motor.

For rate of flow measurements, the induction tachometer and thermal converter located on the Centrimax meter body generate a millivoltage related to the speed of the integration counter . . . and to the rate of flow. This millivoltage is transmitted to the Speedomax Rate of Flow Recorder, located so its indicated and recorded data are readily available.

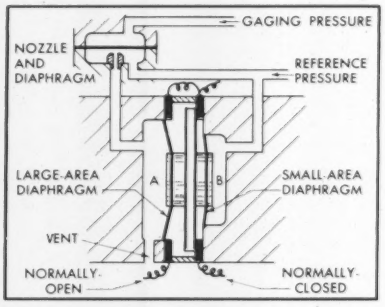
Integration is highly accurate—error is held within narrow limits. At maximum flow the error is within $\pm 0.5\%$ of the theoretical value. At 25% of maximum flow the error is within $\pm 1.0\%$, which amounts to an equivalent full-scale error of less than $\pm 0.25\%$ . . . (*From new 4-page Product Data Sheet* 463-170. *Leeds & Northrup Co., 4907 Stenton Ave., Phila. 44, Pa.*)

For this literature circle **170** on inquiry card.

Automatic Gaging

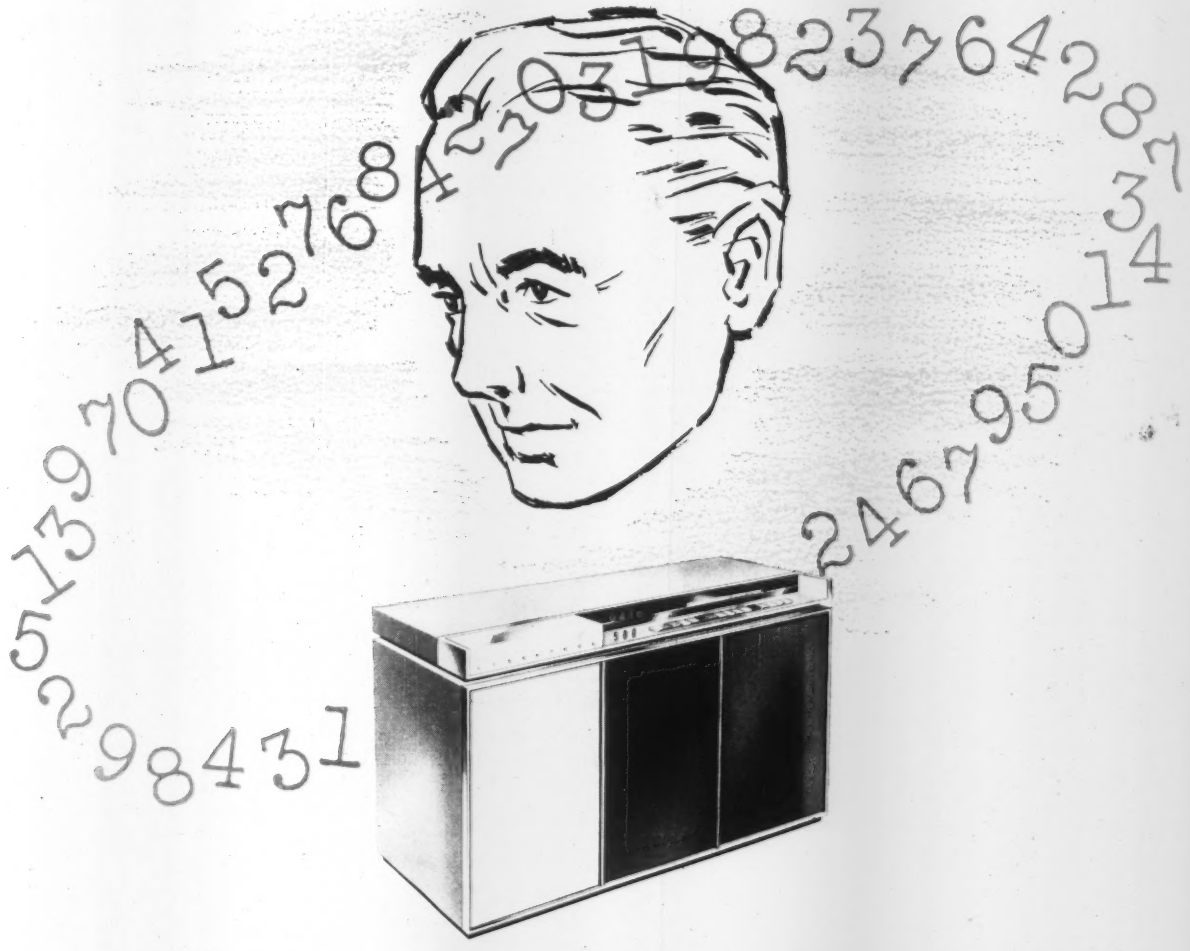
The Moore Automation Controller is an all-purpose air-gaging unit which converts its pneumatic size-signal to either a two-point or a four-point electrical output (depending upon the model selected). The two-point unit is usually set to control at the work-tolerance limits. The four-point unit also provides approach zones to the tolerance limits . . .

All Moore Scanning Stations and Automation Controllers use this "pneumatic snap-action" relay to convert the pneumatic size-signal to an electric output . . . The Schematic diagram shows one switch element in the "normal" condition, with the cut-off point



(reference) pressure present in both A and B chambers. Due to the large area of diaphragm A, the switch plate is held firmly against the "normally closed" contact. When the pressure of the gaging signal rises above the reference pressure, the control diaphragm closes the nozzle, shutting off further flow of reference pressure to the A chamber. Because of the large vent, the pressure in the A chamber instantly falls to zero. Since chamber B still contains the reference pressure, its diaphragm immediately moves the switch plate to the left, breaking the "normally-closed" and making the "normally-open" contact . . . (*From new 24-page Bulletin* 8008, *Moore Products Co., H & Lycoming Sts., Phila. 24, Pa.*)

For this literature circle **171** on inquiry card.



GPE Controls LIBRATROL®-500

...anyone with a head for figures can program this digital computer for on-line application!

Any accountant or engineer – anyone who can work out a sequential problem on an ordinary desk calculator – can program the GPE Controls Libratrol-500. It is by far the easiest digital computer to program and operate.

For example, command and address data are a part of every word. This arrangement insures accurate programming without a great deal of specialized knowledge and training. An engineer can learn to program a simple problem in two hours.

Libratrol-500 was designed for industrial automatic control–designed for simple yet comprehensive operation. Your GPE Controls man can give you all the facts.

Test vehicles and pilot plants as well as industrial processes can benefit from the flexibility and simplicity of the Libratrol-500.

See the Libratrol-500 IN ACTION at the 5th World Petroleum Congress Exposition, Booth 376, New York, June 1-5

Write for descriptive literature

GPE Controls, Inc. (formerly Askania Regulator Company)
240 East Ontario Street • Chicago 11, Illinois

GPE Controls | A GENERAL PRECISION COMPANY

A Subsidiary of GENERAL PRECISION EQUIPMENT CORPORATION

For more information circle **44** on inquiry card.

Case Type No. 1279.

Case Type No. 1379 is Alumalife, while similar case Type No. 1079 is Cast Iron.

Case Type No. 1377.

In such cases DURAGAUGES® naturally serve longer

You have a choice of three case materials—Alumalife®, a special aluminum alloy, Cast Iron, rugged and durable, Phenol, tough and rigid plastic—plus the unique "Maxisafe" design when you specify Ashcroft Duragauges.

All three case materials use a chrome plated, die-cast retaining ring to keep out harmful fumes and dirt. Case construction simplifies servicing—the entire system can be easily removed for recalibration or repair.

The "Maxisafe" case provides absolute protection to the viewer, easy and quick access to the tube and movement assembly. An integrally cast solid wall separates the dial from the tube and movement. A safety cover plate on the back is held in position by a knurled knob.

Regardless of your gauge case requirements, there's an Ashcroft Duraguage to do the job. Contact your local Ashcroft Gauge Distributor for complete facts.

Ashcroft Duragauges are available in pressure ranges from 15 psi (or vacuum) minimum to 100,000 psi.

CASE MATERIALS, TYPE NUMBERS, MOUNTING AND SIZES

CASE	TYPE NO.	BACK FLANGE	MOUNTING		CONNECTION		DIAL SIZE
			WALL	FLUSH	LOWER	BACK	
Black Alumalife	1379	Yes	Yes	Yes	Yes	Yes	4½", 6"
Black Cast Iron	1079	Yes	Yes	Yes	Yes	Yes	4½", 6", 8½" 10", 12"
Black Phenol, Turret Design	1279	No	Yes	Yes*	Yes	Yes	4½", 6", 8½"
Black Alumalife**	1377	No	No	Yes	No	Yes	4½", 6", 8½" 10", 12"

*May be flush mounted by using Flush Mounting Ring, Catalog No. 1278.
**The 10" and 12" dial sizes are made in cast iron only.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

ASHCROFT PRESSURE GAUGES

A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

For more information circle **45** on inquiry card.

book reviews

Mathematics and Logic for Digital Devices, by James T. Culbertson. [C 1958.] D. Van Nostrand Co., Princeton, N. J. 224 p. $4.85. 9 in. The development of digital computers involves a special kind of mathematical reasoning as well as branches of mathematics seldom taught in standard college courses. The only prerequisite here is college algebra. Includes permutations, combinations and probability and proceeds of study of Boolean algebra.

Guide to the Literature of Mathematics and Physics Including Related Works on Engineering Science, ed. 2, by Nathan Grier Parke III [C 1958.] Dover Publications, New York 10, N. Y. 436 p., unbound. $2.49. 8 in. A remarkable piece of bibliographic work. Includes books and some magazine articles.

Handbook of Electronic Circuits, by RCA Service Co., Inc., [c1958], Howard W. Sams & Co., Inc., Indianapolis 6, Ind., 66 p., $1.00, 8½″ x 11″. Contains basic circuits for power supplies, receivers, transmitters, limiters, f-m detectors, radar-television, filters, and controls.

Messen und Regeln in der Chemischen Technik, edited by J. Hengstenberg, B. Sturm, and O. Winkler, [1957], Springer-Verlag, Heidelberger Platz 3, Berlin-Wilmersdorf, West Germany, 1261 p., clothbound, 10″ x 6″. A comprehensive treatment of measurement and process control in the chemical industry in nine chapters. Two thirds of the volume deal with theory and practice of temperature, flow and level, pressure, analytical, electrochemical, and special measurements. Process control, "the hardware," and plant organization form the balance. State of the art in the U. S. includes pneumatic and electronic controllers by Foxboro, Leeds & Northrup, Minneapolis-Honeywell, Moore Products, Proportioneers, Swartwout, and Taylor; also ISA symbols.

Registrierinstrumente, by Albert Palm, second, revised edition by H. Roth and E.-G. Schlosser, [1959], Springer-Verlag, Heidelberger Platz 3, Berlin-Wilmersdorf, West Germany, 255 p., cloth-bound, 9¼″ x 6½″, DM 27.00. Recorders developed since 1950, the publication year of the first edition, have been added, including CR Oscillographs. Emphasis is laid on description of various drives.

A New Addition

The model 1016A is the newest addition to the growing Bryant line of standard magnetic storage drums. Like other Bryant drums, it can be provided with custom-designed patterns of storage, and recirculating register tracks.

A full line of Bryant standard or special magnetic read/record heads meets the varying requirements of all computer manufacturers.

The exclusive foolproof Bryant head-setting design means real economy for original set-ups or change-overs.

Every leader in the electronics field has benefited from Bryant's 25 years of experience in ultra-high-speed precision rotating equipment.

Features:

- 10″ Diameter by 16″ long magnetic surface. (cabinet dimensions 25 x 25 x 35″)
- Guaranteed accuracies of drum run-out to .00010″ or less.
- Integral drive-Bryant precision motors (900 to 3600 RPM).
- Capacity over 1,500,000 bits.
- Up to 350 KC.
- Accommodates up to 20 magnetic read/record heads per inch with standard designs.
- Precision ground high density magnetic oxide coating. (Another Bryant exclusive)
- Super precision ball bearing suspension.
- Vertical mounting for trouble-free operation.

Special Models: If your storage requirements cannot be handled by standard units, why not let Bryant assist you in the design and manufacture of custom-made drums? Available speeds from 60 to 120,000 R. P. M., with storage up to 6,000,000 bits.

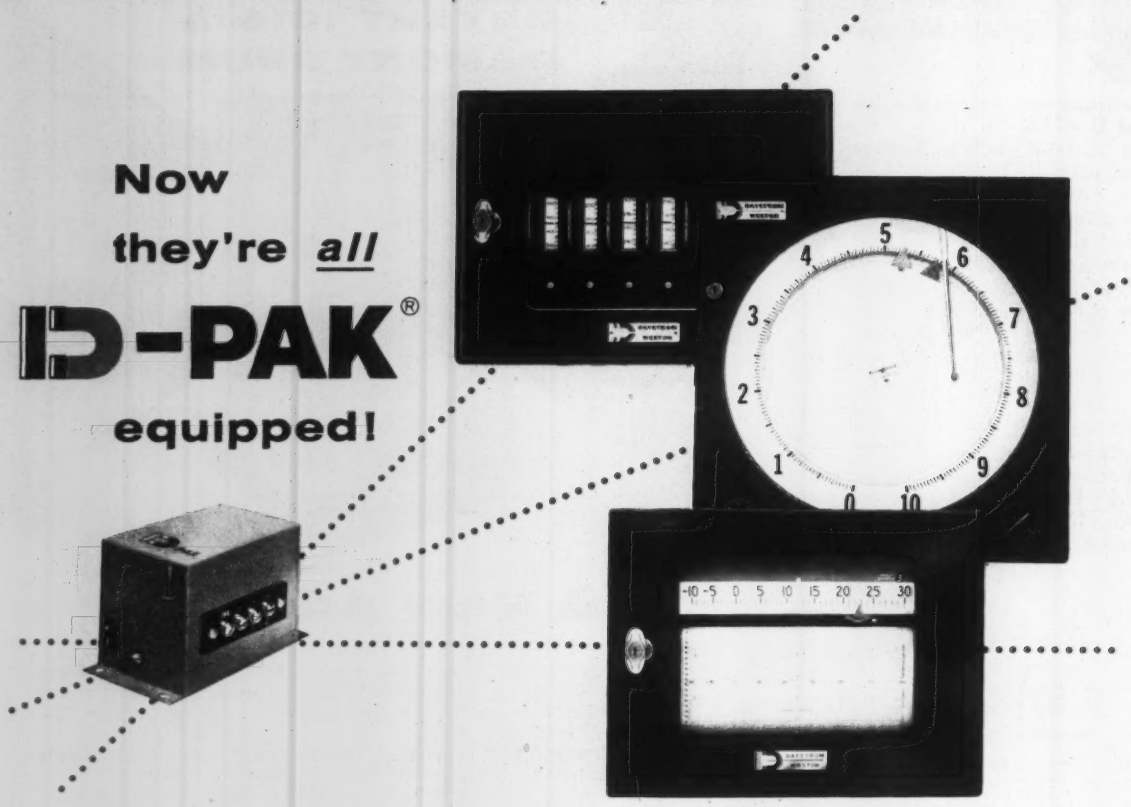
BRYANT COMPUTER PRODUCTS DIVISION

P. O. Box 620-I, Springfield, Vermont, U. S. A.

DIVISION OF BRYANT CHUCKING GRINDER CO.

For more information circle **46** on inquiry card.

Now they're *all* D-PAK® equipped!



Now Daystrom-Weston offers a revolutionary constant current source in every recording and controlling potentiometer

The D-PAK is a solid state, constant current source of sufficient precision for industrial instrument service . . . with plenty to spare. It eliminates many conventional components, such as, batteries . . . standard cells . . . standardizing mechanisms — *and* their maintenance. The D-PAK means continuous accuracy, with no interruptions in measurement or control for standardization. And it functions indefinitely because there are no mechanical moving parts.

D-PAKs are now standard equipment throughout the Daystrom-Weston potentiometer instrument line. Every instrument they serve is a far simpler . . . more stable . . . trouble-free . . . full-time monitor.

For further information, contact your local Weston representative, or write to Daystrom-Weston Sales Division, Newark 12, N. J. *In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ont. Export: Daystrom International, 100 Empire St., Newark 12, New Jersey.*

DAYSTROM WESTON

World leader in measurement and control

DAYSTROM-WESTON INDUSTRIAL INSTRUMENTS include a full line of **recording and controlling potentiometers** with strip and circular charts; **mechanical recorders and indicators** for pressure, temperature and flow; and **non-indicating controllers,** both electric and pneumatic.

For more information circle **47** on inquiry card.

BOOKS—CONTINUED

Ordinary Differential Equations, by Wilfred Kaplan [c1958.] Addison-Wesley Publishing Co., Reading, Mass. 534 p. $8.50. 9¼ in. Based on author's current work in instrumentation program at University of Michigan.

Aircraft Communications Systems, by J. H. H. Grover. 1958. Philosophical Library, New York 16, N. Y. 127 p. $6. 8¾ in. Very brief treatment of transmitting and receiving equipment and instrumentation.

Fine Particle Measurement; Size, Surface, and Pore Volume, by Clyde Orr, Jr. and J. M. Dallavalle. [1959.] Macmillan Co., New York 11, N. Y. 349 p. $10.50. 8½ in. Methods and equipment for more than seventy techniques.

Fundamentals of Transistors, ed. 2, by Leonard M. Krugman. [c1958.] John F. Rider, New York 11, N. Y. 168 p., unbound. $3.50. 8½ in. Includes physics of semiconductors, operation of transistors.

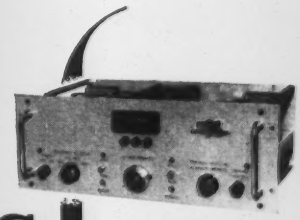
Digital Techniques for Computation and Control, by Martin L. Klein, Harry C. Morgan and Milton H. Aronson. [1958.] Instruments Publishing Co., Pittsburgh 12, Pa. 392 p. $6. 8½ in. Offered as the first exhaustive published treatment of the subject.

Sampled-data Control Systems, by John R. Ragazzini and Gene F. Franklin. 1958. McGraw-Hill Book Co., New York 36, N. Y. 331 p. $9.50. 9¼ in. The theory here developed serves as a common base for analysis and synthesis of linear digital systems, pulsed continuous systems, and their combinations as found in practice. Presupposes knowledge of differential equations, Laplace transformation, linear feedback control theory, and the elements of probability and statistics.

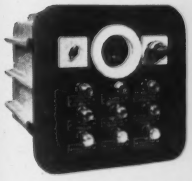
Economic Operation of Power Systems, by Leon Kirchmayer. 1958. John Wiley & Sons, New York 16, N. Y. 260 p. $12. 9¼ in. Emphasizes theoretical developments, and the use of analog and digital computers to obtain transmission loss formulas and generation schedules.

COX *Electronic*

FLOW MEASURING SYSTEM

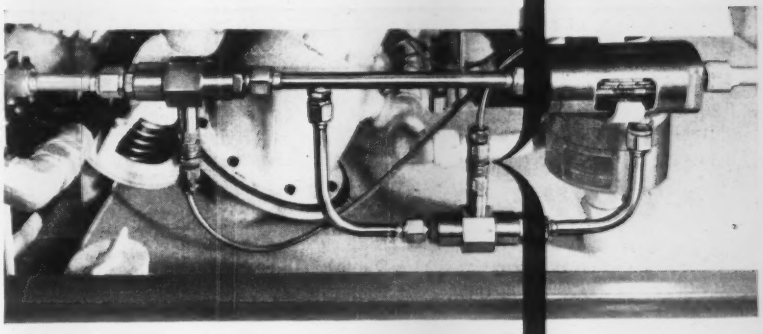


RACK MOUNTED INDICATOR

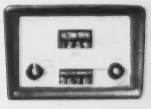


EXPLOSION-PROOF INDICATOR

COX Instruments brings you the most advanced development in flow measuring equipment: *A calibrated, integrated flow measuring system with a guaranteed system accuracy of ± ½% and flow ranges of 1:1000.*



Developed for the missile age, the COX *Flow Measuring System* consists entirely of COX-built components. It comprises a turbine flow transducer; a choice of continuous reading digital indicators, counter, or dial indicator; and a manifold assembly with a unique automatic by-pass valve. All are calibrated for *system accuracy* of ½%.



TRANSISTORIZED INDICATOR

DIAL INDICATOR

COX *Flow Measuring Systems* are in use in many aircraft and missile industry laboratories. We welcome the opportunity to tell you more about them.

Write for our new bulletin No. 2027. *Cox Instruments Division, George L. Nankervis Company, 15400 Fullerton Avenue, Detroit 27, Michigan.*

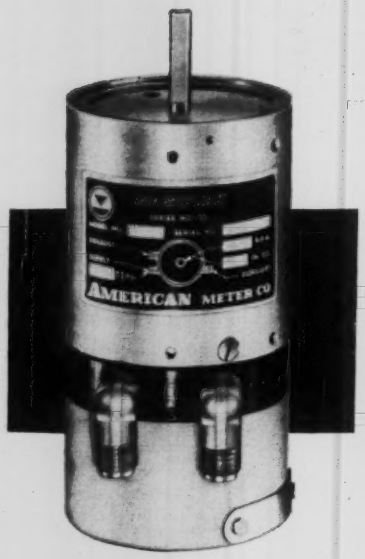
COUNTER

Precision Instruments Since 1912

7391

COX Instruments

For more information circle **48** on inquiry card.



AMERICAN®

GASCLOK

POWER DRIVE

Completely self-contained gas or air-powered instrument driving and timing unit for long, trouble-free operation in remote locations. The GASCLOK delivers more than 20 times the torque of conventional spring-wound mechanisms. Continuous timing accuracy is unaffected by a ± 20% variation in supply pressure.

Inherently explosion proof and self-starting, the GASCLOK is ideal as original or replacement equipment for strip chart and conventional circular chart instruments. The timing mechanism is internally sealed to prevent corrosion, and all power unit parts exposed to gas are aluminum or stainless steel. Large area internal ports prevent clogging. Normal air or gas consumption 5 cfh . . . operating pressure 5 psi . . . rotation 2 rpm.

AMERICAN®
METER COMPANY
INCORPORATED (ESTABLISHED 1836)

Executive Offices: Philadelphia 16, Pa.
Sales offices in principal cities.

For more information circle **49** on inquiry card.

panhandle pete

RUSSIAN REPORT

Russian secret police check everywhere for clues.

WESCO!, not a company to be the last in anything, has sent its genial sales manager Waldo Klappsaddle to Russia, to find out just what the state of our field is. *INSTRUMENTS AND CONTROL SYSTEMS* is proud to bring to American instrument men everywhere this first-hand account of just what is going on in that land.

MHA: "Mr. Klappsaddle, did you find that Russians are ahead or behind us in instrumentation?"

W. K.: "There is no doubt that they are behind in many fields because their instruments are copies of some old American instruments in some fields. In other fields, of course, they are ahead."

MHA: "Was there anything significant in their cities or way of life?"

W. K.: "The Oriental construction of some of the older buildings is very significant."

MHA. "Did you see many instrumentation installations?"

W. K.: "Yes, I saw instrument installations in universities, steel mills, chemical plants, and small manufacturing plants."

MHA: "Are they equipped with modern instruments?"

Russian secret policeman observes suspicious cookies.

W. K.: "Some have some very interesting instrumentation—most seem to be pretty far behind our most advanced instrumentation. Of course some of their instrumentation is ahead of many of our old-fashioned plants."

MHA: "To what do you ascribe their success in some technical fields?"

W.K.: "Their education system is superior. In Russia the scholastic standards are much higher. The students are even paid to go to college."

MHA: "Should the American Federal government support education here like the Russians do?"

W. K.: "Our free system of local control is far superior to their regimented system. No, we should not copy them."

MHA: "What should we do to upgrade our school system?"

W. K.: "Make the students work harder, longer hours, go to school on Saturday, do more homework. Raise academic standards."

MHA: "Were the styles and fashions very modern?"

W. K.: "First thing I noticed was the lack of style in clothes. The women were very unstylish and unattrac-

Russians (many are top secret policemen) cross street.

tive at first. However they became very attractive by the time I left Russia."

MHA: "Did you attend any technical conferences?"

W. K.: "Oh yes, I attended a power instrumentation conference, International Cybernetics conference, and an iron and steel automation conference."

MHA: "What did you learn of significance?"

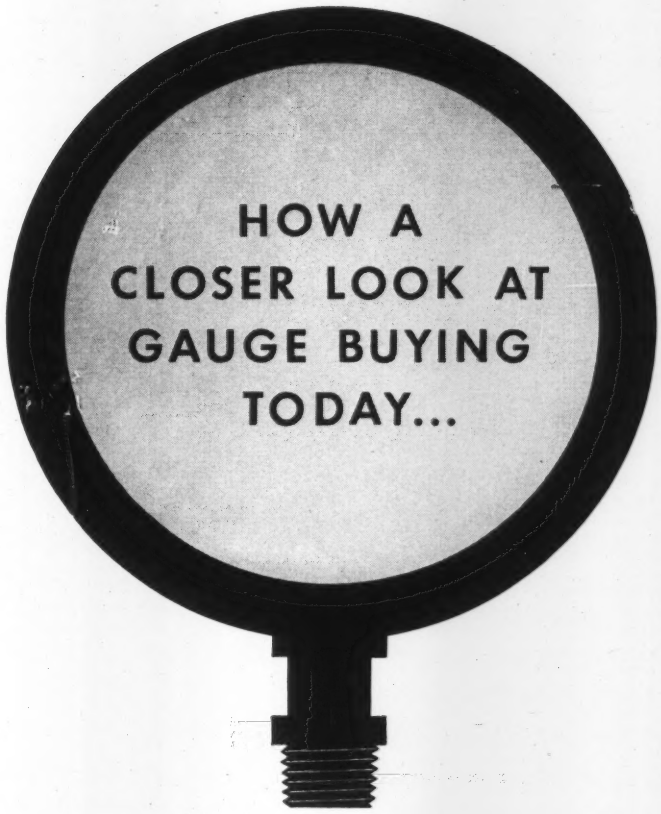
W. K.: "Of course I don't understand Russian. However, I learned as much as the average Russian engineer listening to those papers because they told me they didn't understand most of the math either. Their theory is very theoretical. We had better meet this challenge soon."

MHA: "What did this trip cost WESCO?"

W. K.: "Only $4,000."

Panhandle Pete

P.S. Photos 2 and 3 courtesy E. G.—who (we hope) has a sense of humor.

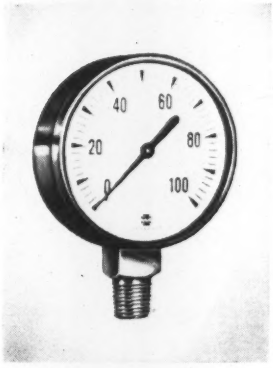


can give you a tighter grip on gauge costs!

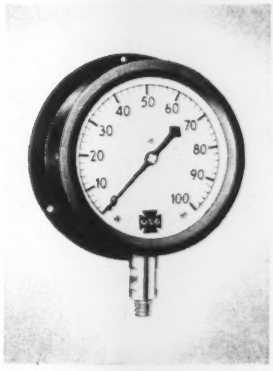
Been looking at gauge buying in your plant as "routine"? In terms of gauge performance you need, accuracy you get, price you pay . . . and how and where you buy? You can pick up real savings with a closer look at your gauge requirements . . . and at what United States Gauge offers. USG features the world's largest stock of indicating dial pressure gauges. Over 50,000 standards, plus specials, with all possible choices of sizes, case stylings, pressure ranges and case materials . . . up to and including the finest gauges of highest accuracy. One source meets 99% of your pressure gauge needs, with the exact gauge for the exact purpose at the right price. And one phone call to your USG distributor taps that source. See the Yellow Pages, or write for catalogs and name of your nearest USG distributor today.

UNITED STATES GAUGE

Division of American Machine and Metals, Inc., Sellersville, Pa.



Replacement costs too high? Volume - priced, precision - built USG drawn-case gauges are the money-savers for replacement of any A.S.A. Grade B gauge in your plant (accuracy of 2% guaranteed). These standbys are specified by more than 60% of original equipment manufacturers today. Proof of USG reliability and value! *Write for Catalog 64A.*

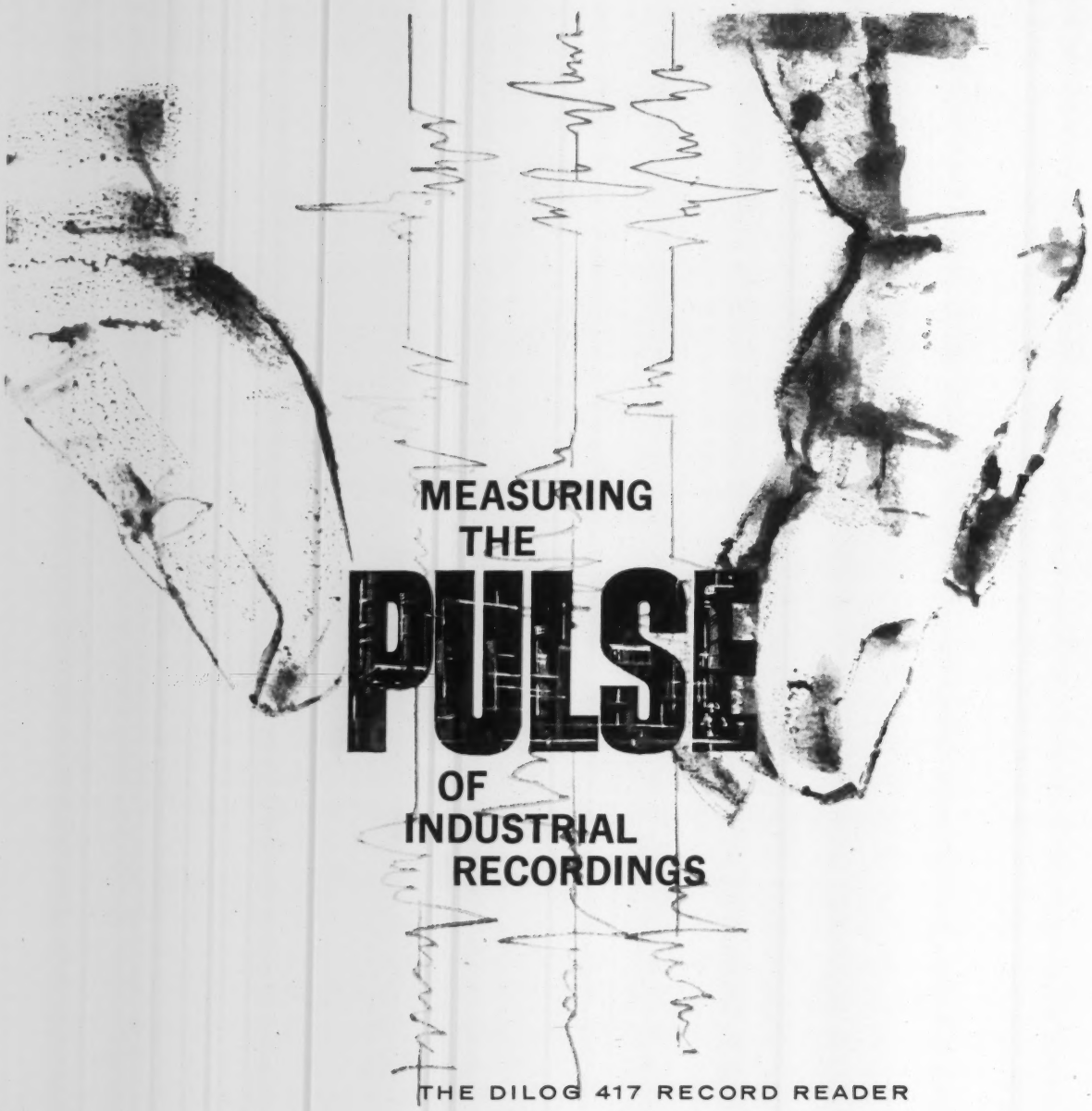


Paying a premium for quality design, reliability? Check the new USG A-Line, premium design at savings up to 40% of premium prices! Meets A.S.A. Grade A Standards, including accuracy of 1%. Wide range of cases, sizes, movements, pressures cuts *you* in on A-Line savings wherever you need dependable gauge performance. *Write for Catalog 305.*

Paying for performance you don't get? Look at the USG Supergauge® line. Built like a watch to A.S.A. specifications for Grade AA Test Gauges, these gauges pay for themselves in long-lived, dependable performance and lower maintenance costs. Accurate to 0.5% of scale range. Full selection of case styles, sizes and options. *Write for Catalog 1819.*

Losing out on highest accuracy? USG Test Gauges are the elite of the industry, equalling or exceeding A.S.A. Grade AA standards with accuracy as high as 0.2 of 1%! Styles, sizes and case materials for all types of laboratory and test uses. You can't buy higher quality and precision in a test gauge! Get your money's worth at USG. *Write for Catalog 400.*

For more information circle **50** on inquiry card.



MEASURING THE PULSE OF INDUSTRIAL RECORDINGS

THE DILOG 417 RECORD READER

Keeping a finger on the pulse of automatic and semi-automatic data recording systems of modern industrial facilities requires advanced data reduction systems. In the fields of petroleum, chemical, utilities, medical, pharmaceutical, and similar industries —where critical testing techniques demand *accurate* and *immediate* reduction of data... the Data Instruments DILOG 417 Record Reader provides the most economical and efficient method of translating *both* paper and film oscillographic records to useful digital form. The extra-large viewing and measuring area allows quick and accurate translation of data into any desired digital form . . . cards, tape, printed lists.

Pioneers in Instrumentation For Data Analysis

DATA INSTRUMENTS

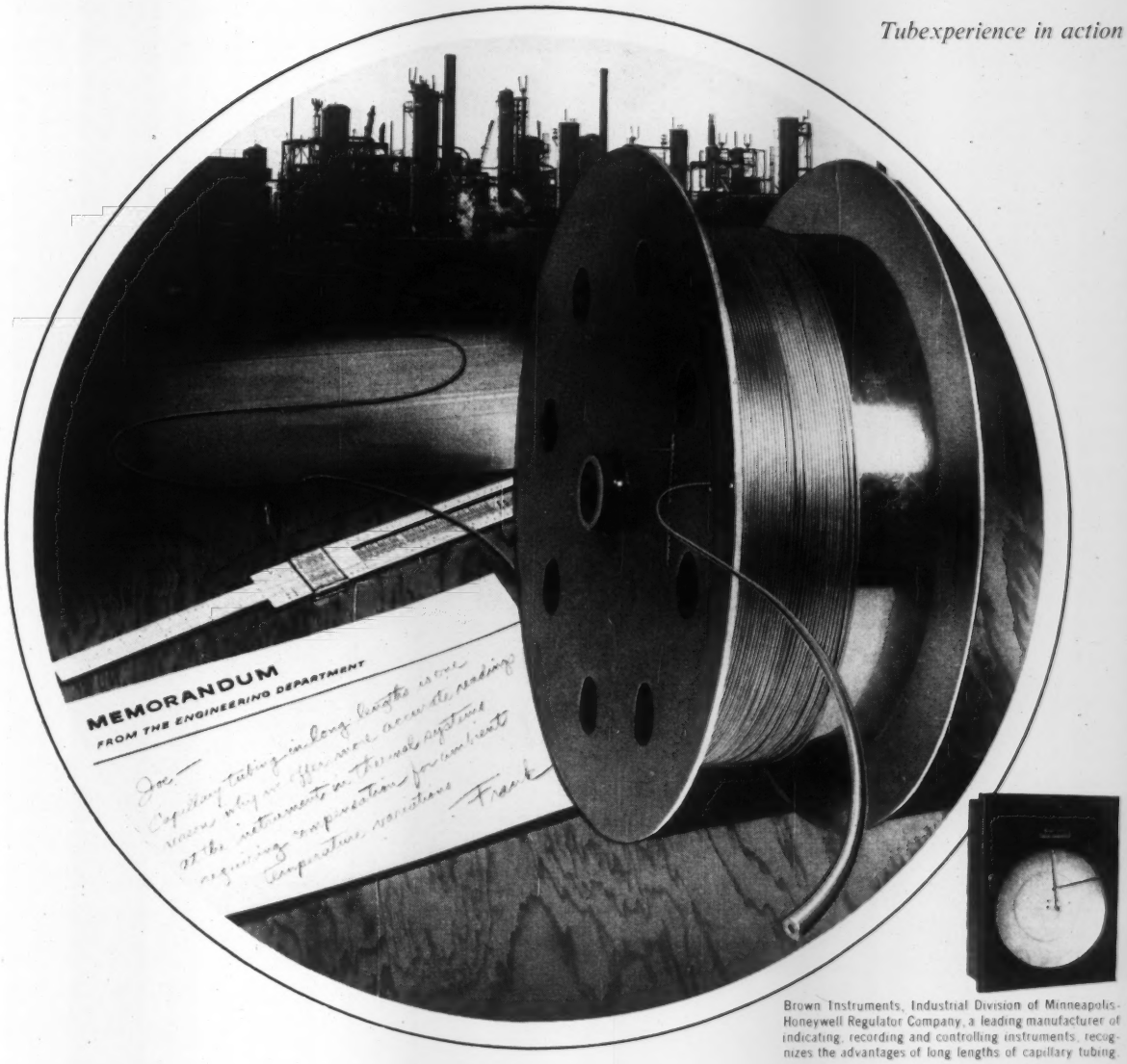
Ask for the complete story of DILOG 417. Write, wire, or phone:

DATA INSTRUMENTS
DIVISION OF TELECOMPUTING CORPORATION

12838 SATICOY ST., NORTH HOLLYWOOD, CALIFORNIA, PHONE: STANLEY 7-8181

For more information circle **51** on inquiry card.

Tubexperience in action



Brown Instruments, Industrial Division of Minneapolis-Honeywell Regulator Company, a leading manufacturer of indicating, recording and controlling instruments, recognizes the advantages of long lengths of capillary tubing.

Up to 3000 ft. of capillary tubing in 1 piece

Seldom does an instrument installation require 3000 ft. of capillary tubing in one piece—the quantity is normally much less. But the advantages of long lengths are numerous. A simple long length of capillary tubing has greater ID uniformity than a series of short lengths separately produced. This permits more accurate transmission of data between instruments controlling a process. Instrument manufacturers find that long lengths reduce scrap. They also lessen the number of setups required and the costs of inserting the capillary tubing in flexible metallic protective sheathing.

Superior has spent years in the development of manufacturing processes and quality control procedures for the production of close tolerance tubing. ODs range up to $^{3}/_{16}$ in., IDs from .004 through .040 in. Analyses include Types 304, 316, 321, 347 and 446 stainless; also Monel, Inconel, nickel and carbon steel alloys. Data Memorandum No. 11 gives complete details —let us send you a copy. Superior Tube Company, 1968 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

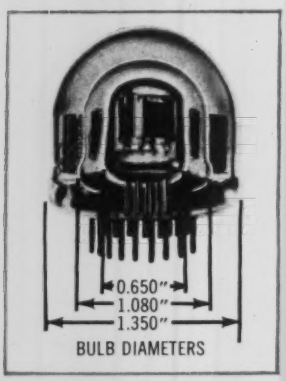
All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD.

West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331

For more information circle **52** on inquiry card.

Burroughs
NUMERICAL READOUT TUBE
NIXIE®

lightest weight
any
readout



ALL ELECTRONIC IN LINE READOUT
CONTAINING TEN DIGITS "0" THRU "9"

MINIATURE	STANDARD	SUPER
0.2 oz.	0.4 oz.	0.8 oz.

NIXIE TUBE EXCLUSIVE FEATURES:

- ALL ELECTRONIC
- LOWEST COST
- LOWEST POWER
- MOST READABLE FOR NUMBER SIZE
- SMALLEST VOLUME ANY NUMBER SIZE
- MAXIMUM TEMPERATURE. SHOCK AND VIBRATION SPECS

ELECTRONIC CONTRIBUTIONS BY
Burroughs Corporation
ELECTRONIC TUBE DIVISION
Plainfield, New Jersey

For more information circle 53 on inquiry card.

events

April 25-30

41st Annual Meeting of Scientific Apparatus Makers Association, Greenbrier, White Sulphur Springs, West Va. For information write Jim Irving, SAMA, 20 N. Wacker Dr., Chicago 6, Ill.

May 6-8

1959 Electronic Components Conference, IRE, EIA, AIEE and WCEMA, Benjamin Franklin Hotel, Philadelphia, Pa. Write Bernard F. Osbahr Electronic Industries, Chestnut & 56th Sts., Philadelphia 39, Pa.

May 11-13

Instrumentation And Computation In Process Development And Plant Design, Central Hall, Westminister, London, S.W.1, England. For information write Institution of Chemical Engineers, 16 Belgrave Sq., London S.W.1, England.

May 14-15

Seventh Annual Meeting of Operations Research Society of America, The Shoreham Hotel, Washington, D.C. For information write David A. Katcher, 4608 Morgan Dr., Chevy Chase 15, Md.

May 14-16

Tenth Annual National Conference and Convention, sponsored by the National Institute of Industrial Engineering, Biltmore Hotel. Atlanta, Ga. For information write J. Frederick Medford, 8246 Roberts, Dunwoody, Ga.

May 18-22

Seventh Meeting on Mass Spectrometry, sponsored by ASTM Committee E-14, Statler Hotel, Los Angeles, Calif. For information write A. G. Sharkley, Jr., U.S. Bureau of Mines, 4800 Forbes Ave., Pittsburgh 13, Penna.

May 20-22

National Spring Meeting of Society for Experimental Stress Analysis, Sheraton Park Hotel, Washington, D.C. For information write Leonard Mordfin, P. O. Box 4996, Washington 8, D.C.

May 21-22

1959 Ohio Valley Instrumentation-Automation Exhibit & Symposium, sponsored by Cincinnati Section ISA. For information contact Richard Surkamp, 8846 Round Hill Rd., Cincinnati 36, Ohio.

May 21-27

International Convention on Transistors, sponsored by the Radio and Telecommunication Section of The Institution of Electrical Engineers, London, England. For information write I.E.E., Savoy Place, London W.C. 2, England.

June 9-12

National Material Handling Exposition, Cleveland Public Auditorium, Cleveland, Ohio. For information write Material Handling Institute, Inc., Suite 759, One Gateway Center, Pittsburgh 22, Penna.

June 13-23

International Conference On Information Processing, sponsored by UNESCO, Paris, France. For information write USICIP, Box 4999, Washington 8, D.C.

June 15-19

Symposium on Molecular Structure and Spectroscopy, sponsored by Dept. of Physics and Astronomy, Ohio State University, will be held on campus. For information write R. A. Oetjen, Ohio State University, Columbus 10, Ohio.

June 16-19

Industrial Engineering Seminars, sponsored by Cornell University, will be held on campus. For information write Andrew Schultz, Jr., Cornell University, Ithaca, N. Y.

August 17-28

Courses In Frontier Research On Digital Computers, sponsored by University of North Carolina, will be held on campus. For information write James G. Steagall, University Extension Div., Box 1050, Chapel Hill, N. C.

June 17-19

2nd Nuclear Instrumentation Symposium, Idaho Falls, Idaho. For information write H. S. Kindler, ISA, 313 6th Ave., Pittsburgh 22, Penna.

August 18-21

Western Electronic Show and Convention, San Francisco, Calif. For information write WESCON, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

August 24-26

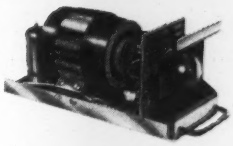
Appalachian Gas Measurement Short Course, sponsored by University of West Virginia, will be held on campus. For information write School of Mines, Morgantown, West Virginia.

August 24-29

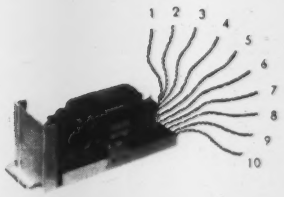
Infrared Spectroscopy Institute, sponsored by Fisk University, will be held on campus. For information write James R. Lawson, Fisk University, Infrared Spectroscopy Institute, Nashville, 8, Tenn.

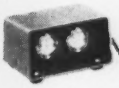
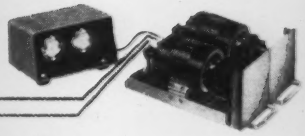
November 16-20

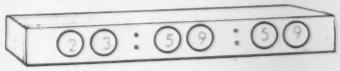
Fifth International Automation Exposition, The New York Trade Show Building, 500 Eighth Ave., New York City. For information write Richard Rimbach Associates, Mgmt., 845 Ridge Ave., Pittsburgh 12, Penna.

NO OTHER  COUNTERS PROVIDE

DIRECTLY

TEN INDIVIDUAL OUTPUTS 

MULTIPLE REMOTE  READOUT 

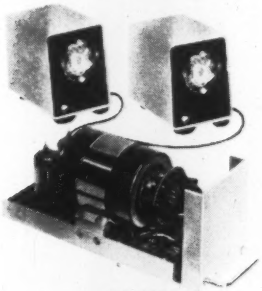
VARIABLE COUNT 

① ③ ⑤ ② ULTRA LONG LIFE IN-LINE READOUT

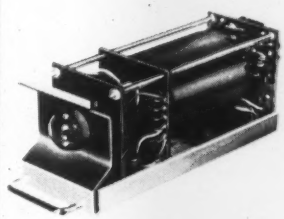
Burroughs **Visual and Electronic Error Free** Decade Counters are based on the unique properties of the Beam Switching Tube wherein a single cathode controls an electron beam to 10 outputs. In contrast to other types of counters, the Beam Switching Tube output is directly capable of driving an in-line indicator such as the Nixie® Tube. This complete line of seven counter types is designed for maximum reliability while providing advanced electrical characteristics not readily obtainable with other components. Such features include:

- Ultra reliable operations at one megacycle and over
- Electronic resetting in less than 1 microsecond
- Electrical output in each of its 10 positions
- Provisions for BOTH LOCAL AND REMOTE INDICATORS
- Extreme noise insensitivity
- Minimum components and power consumption

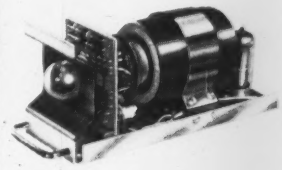
Write for eight pages of circuit information — Bul. 826A.



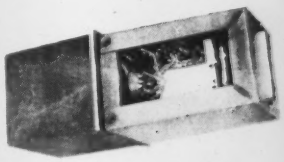
DC 106B



DC 101



DC 105, DC 106A



DC 130 — Mil Spec Counter

ANOTHER ELECTRONIC CONTRIBUTION BY

Burroughs Corporation

ELECTRONIC TUBE DIVISION

Plainfield, New Jersey

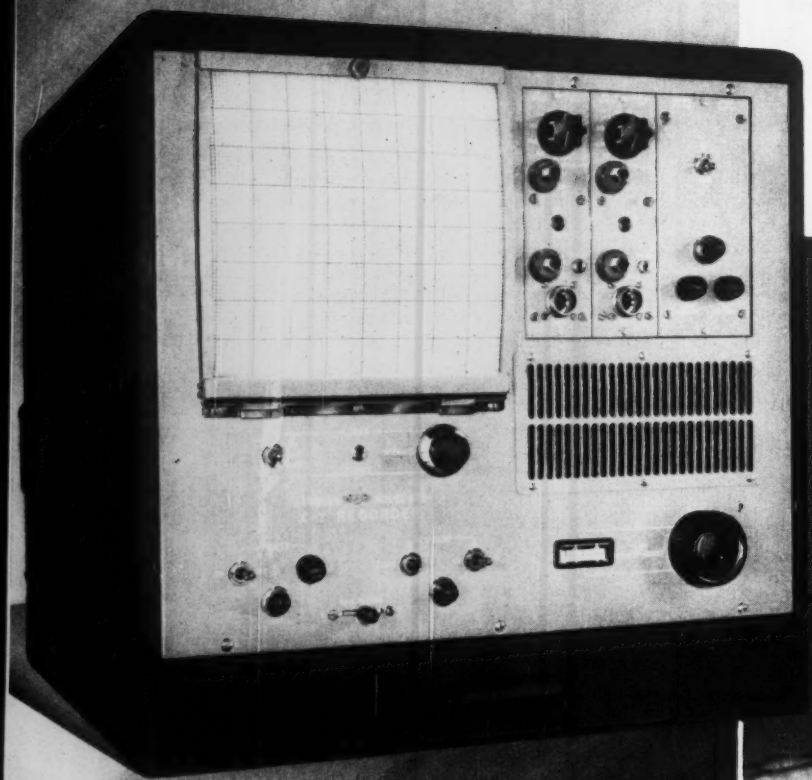
For more information circle **54** on inquiry card.

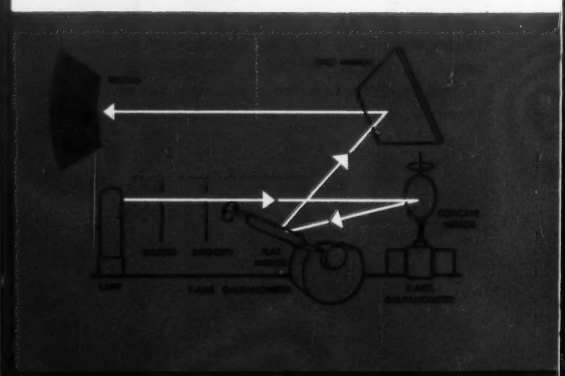
100 CPS X-Y RECORDING

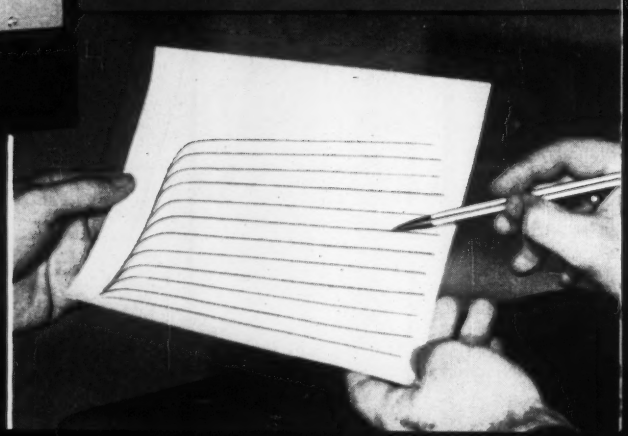
with immediate readout

THE NEW SANBORN MODEL 670 OPTICAL X-Y RECORDER HAS

- ★ 1% linearity
- ★ frequency response 3 db down at 130 cps independent of amplitude
- ★ writing speeds to 2500 in/sec.
- ★ 8″ x 8″ direct print paper chart
- ★ trace monitoring on phosphorescent screen



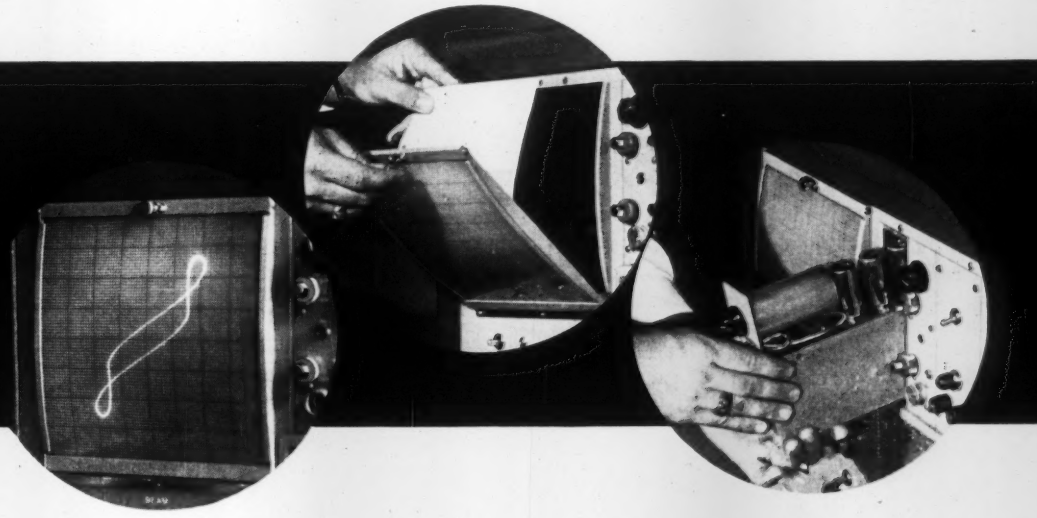




X-Y RECORDING never before possible with electromechanical instruments can now be done with the new Sanborn Model 670 X-Y Recorder. Direct writing on ultraviolet-sensitive recording paper by a beam deflected by optical galvanometers makes possible the combination of fast writing speed and 130 cps frequency response not found in any other X-Y recorder. Transistor characteristics, acceleration and vibration of mechanical parts and events of similar short duration can be recorded with linearity of *1% of full-scale* and at trace speeds as fast as *2500 inches per second.* Square wave response exhibits no greater than ½% overshoot *at any amplitude;* sensitivities as high as 62.5 uv/inch (depending on preamplifier used).

PLOTS OCCUPY AN 8" x 8" RECORDING AREA and can be previewed or monitored on the instrument's phosphorescent screen. An Axis Record switch to print X and Y axes on the record, and a Beam Intensity Control to assure maximum trace clarity, are among the front panel controls provided. An 8" x 8" sheet of the ultraviolet-sensitive chart paper (stored in drawer at base of cabinet) is easily placed on the back of the hinged screen. Brief post exposure in normal room light is the only developing process.

OPTIONAL INTERCHANGEABLE PREAMPLIFIERS for each axis presently include the Model 850-1300B DC Coupling and Model 850-1200 Phase Sensitive Demodulator; a Carrier Preamplifier, High Gain Preamplifier and a time base generator are now in development. Driver Amplifiers are compact, fully transistorized plug-in units with single-ended input and output. Galvanometers are low resistance, low voltage units of rugged, enclosed construction; sensitivity and damping are independent of coil temperature. Accessible, unitized circuitry also extends to the power supplies — a front-panel plug-in for both preamplifiers and a second supply for both driver amplifiers. A built-in blower provides constant, forced filtered air cooling. The Recorder can be rack mounted in 15¾" of panel space, or housed in its own 20" x 20" x 21¼" optional portable cabinet.



Ask your local Sanborn Sales-Engineering Representative for complete information on the Model 670 X-Y Recorder, or write the Industrial Division in Waltham, Mass.

SANBORN COMPANY

INDUSTRIAL DIVISION • 175 Wyman Street, Waltham 54, Massachusetts

For more information circle **55** on inquiry card.

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters

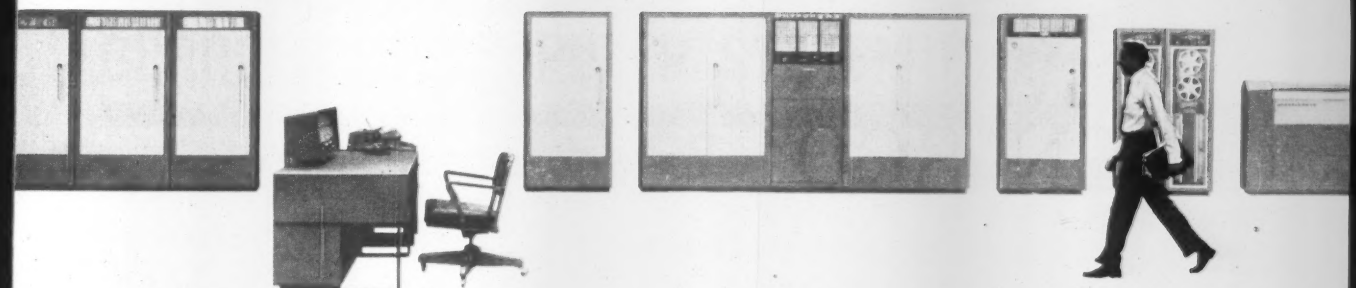
Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

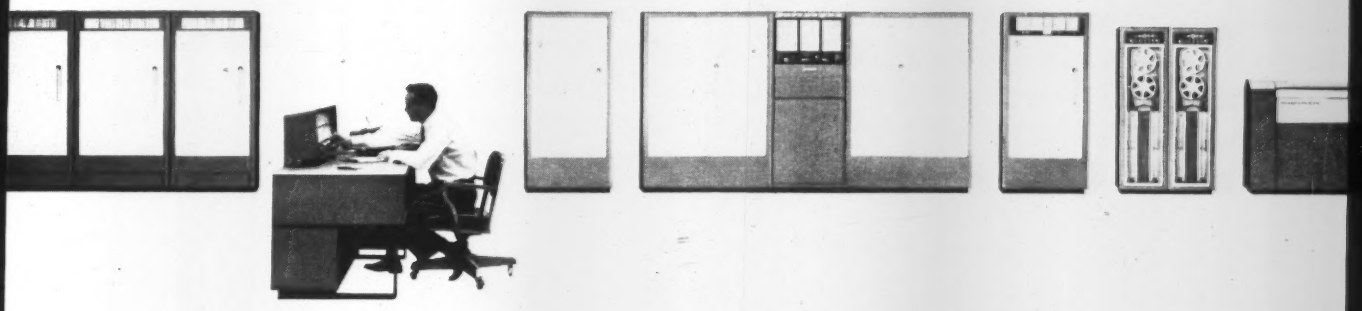
®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

- No oil filters.
- No dust filters.
- No internal lubrication to contaminate air handled.
- No internal wearing parts.
- No valves, pistons, or vanes.
- Non-pulsating pressure.
- Original performance constant over a long pump life.
- Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.



proven again and again: Burroughs 205 Computer



Designed to handle with ease a wide range of computational problems, the Burroughs 205 is delivering results daily in a great variety of scientific and business applications... from refinery design to inventory control, wind tunnel test analysis to insurance premium billing, telemetered data reduction to operations research. The 205 was selected to work on these and countless other tasks because of its speed, 4080 words of memory, ease of program loading, vast magnetic tape storage capacity and multiple-card processing versatility... features which make the 205 today's best dollar-for-dollar computer value. The 205 is just one part of a complete line of Burroughs electronic data processing equipment, helping hundreds of industrial users to save precious man-hours and to solve important problems. Write for 205 brochure, ElectroData Division, Pasadena, California.

Burroughs Corporation

"NEW DIMENSIONS/in electronics and data processing systems"

For more information circle **56** on inquiry card.

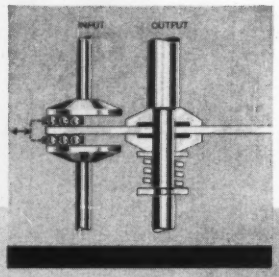
NEW GENISCO CENTRIFUGES

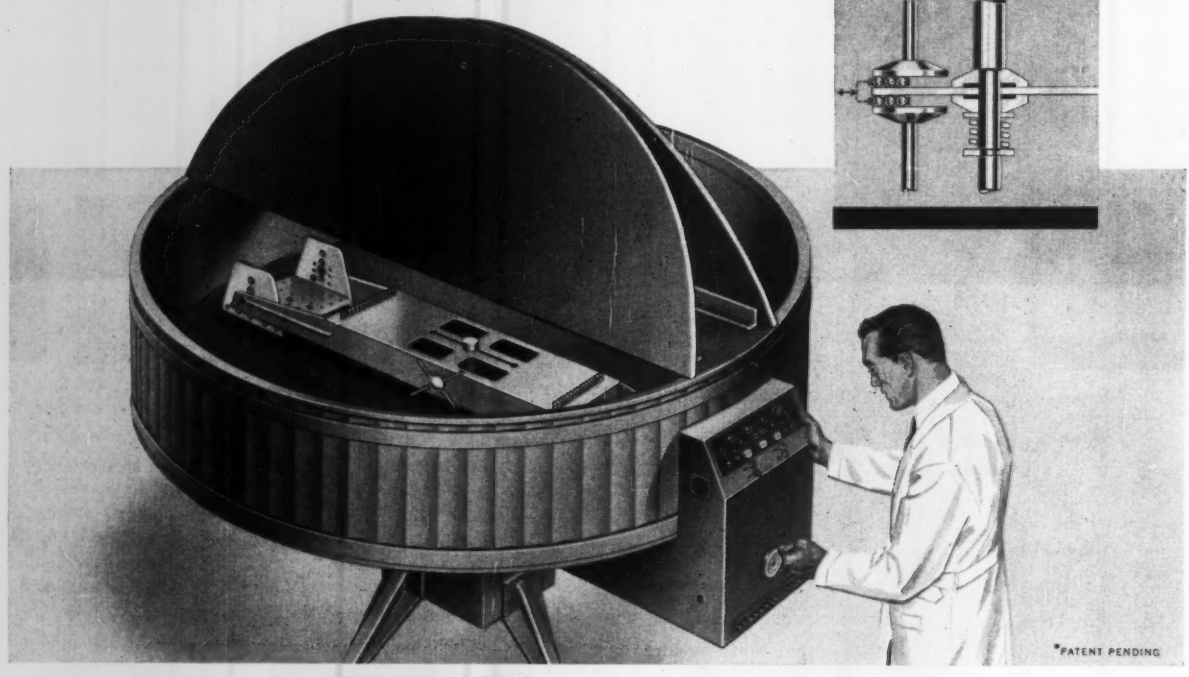
have 10 times greater accuracy, larger centrifugal capacity, greater flexibility, yet are priced lower than any other centrifuges now available.

These new precision centrifuges feature a unique, high-torque, ball-disc integrator drive system. Constancy of boom rotation, including wow and long-term drift, is better than 0.05% at any speed setting—approximately 10 times more accurate than currently available machines. Boom speed is infinitely variable and is measured by an electronic counter built into the console.

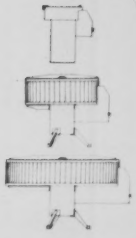
Exceptional flexibility is achieved in the new centrifuges through the use of a "building block" design concept. Machines are assembled from six basic off-the-shelf components: drive system, drive motor, boom, test compartment, console and accessories. You simply select components to meet your specific requirements. Component interchangeability permits easy modification as requirements change. Kits are available for modification by the customer.

Entirely New Drive System
An integral, variable-speed transmission based on the new Rouveral* ball-galaxy principle achieves high torque characteristics while maintaining the inherent accuracies of a hardened steel-to-steel ball-disc integrator.





*PATENT PENDING



BRIEF SPECIFICATIONS

Model No.	Diameter	Test Object Weight	Capacity G-pounds	RPM Max.	G-Range Max.	Test Object Dimensions
A-1010	30" table	50 lbs. dead weight	2,500	670	.1 to 150 g's	
A-1020	60" arm	100 lbs. dead weight	10,000	460	.1 to 150 g's	12" cube
A-1030	96" arm	100 lbs. dead weight	10,000	355	.1 to 150 g's	18" cube

Ratings up to 250 g's can be furnished.

Ask your Genisco representative for complete information today.

Genisco INCORPORATED

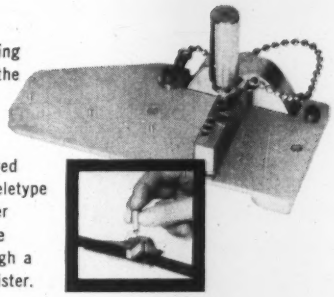
2233 FEDERAL AVENUE • LOS ANGELES 64 • CALIFORNIA

For more information circle **155** on inquiry card.

BURROUGHS COMPUTER SYSTEM COMPONENTS

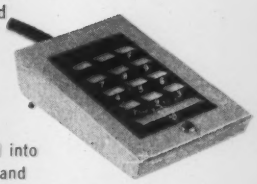
MANUAL TAPE PUNCH

Eliminates the problem of re-inserting perforated tape for repunching in the main perforating unit. A precision unit with particular application as a method for insertion of information into an already prepared tape. It accommodates standard Teletype and Commercial Controls Flexowriter tapes, and corrects up to an 8-hole code. Tape is easily inserted through a guided slot and held in perfect register.



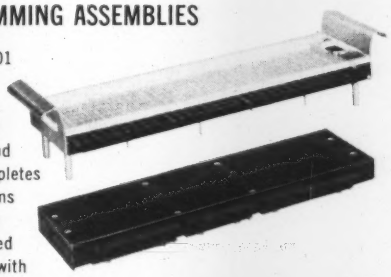
DECIMAL KEYBOARDS

The answer to the widespread need for a modestly priced, versatile manual-input device. Thoroughly proven with the Burroughs 205 and 220 computing systems, the Decimal Keyboard is a 13-key unit that can be readily integrated into a wide variety of data processing and communications systems. Compact, with feather-light touch which provides high speed of input. A 16-key unit is also available.



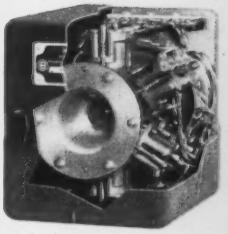
PINBOARD PROGRAMMING ASSEMBLIES

Used in the Burroughs E101 desk-size computer, now individually available as a basic control unit or stored program device. Simple and versatile: a single pin completes a circuit. Complete programs can be quickly changed by inserting previously prepared plug-in units. Expandable, with three types of pinboard receptacle units. Compact: 11¾" by 3⅜".



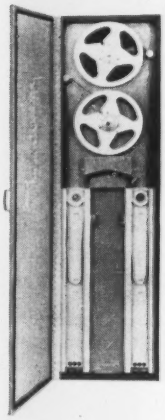
MAGNETIC STORAGE DRUM

A small, high-speed magnetic drum for intermediate storage—proven in use with Burroughs 205 and 220 computing systems. It buffers information between the computer and various input-output units. Revolves at 21, 600 rpm, permitting access to stored data in average time of 1.4 milliseconds. Easy matching with either transistor or vacuum tube circuitry. Furnished complete, including 10 dual read-write head assemblies and drive motor.



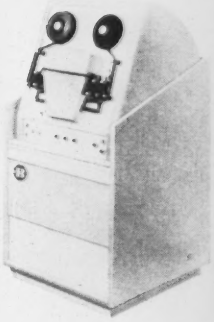
DIGITAL MAGNETIC TAPE TRANSPORTS

Several transports are offered to meet a variety of tape speed and tape width requirements. Bi-directional units operate at speeds up to 75 inches per second. Multiple speed units are also available. Ten-speed transport handles tape at speeds from 1½ to 90 inches per second. All transports incorporate vacuum controlled reel servo systems for gentle tape handling, end-of-tape sensing, fast start and stop, remote and local control, easy threading and dust free operation. A file protection device and air-conditioning manifolds are available. Years of proven reliability in Burroughs computer systems and other digital applications.



PHOTOREADER

Reads 1,000 characters per second... stops on a single character, then reads the next within five milliseconds after restart. The finest and fastest precision perforated paper-tape-reader commercially available as a component. Developed as an input unit for the Burroughs 220 computing system, the Photoreader may be mounted in any standard 19" cabinetry—or ordered already housed in the 220 cabinet, as pictured.

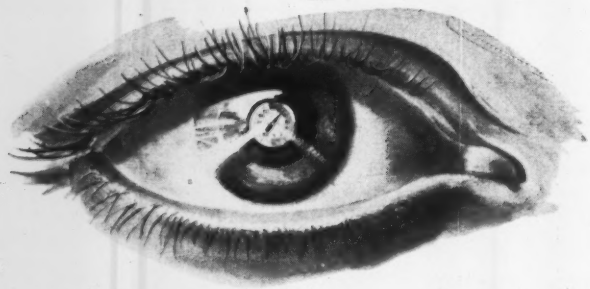


For complete details on these or other Burroughs Computer System Components, write to Component Sales, ElectroData Division, Pasadena, California.

Burroughs Corporation

"NEW DIMENSIONS in electronics and data processing systems"

For more information circle **57** on inquiry card.



What you read is right

The new, patented Maxivision dial on American Bi-Metal Thermometers eliminates the perspective effect of usual pointer-above-dial construction. No parallax! Readings are sure, sharp and accurate – exact working temperatures are always right before your eyes. It is a two-level dial. A raised outer ring, set close to the cover glass, carries the graduations. The index type pointer is on the same plane as the outer ring, with the numerals on a lower level.

What you read is right when American Bi-Metal Thermometers with anti-parallax Maxivision dial are installed at important check points on your processing facilities. Mounting styles, dial sizes, temperature ranges and stem lengths are available to meet the most exacting requirements. Let your nearby industrial distributor help you select the best combination for each location.

American Bi-Metal Thermometer with Maxivision Dial. Suitable for indoor or outdoor service.

MAXWELL MANNING M&M & MOORE, INC. TRADE MARK

A2-58R

AMERICAN INDUSTRIAL THERMOMETERS

A product of

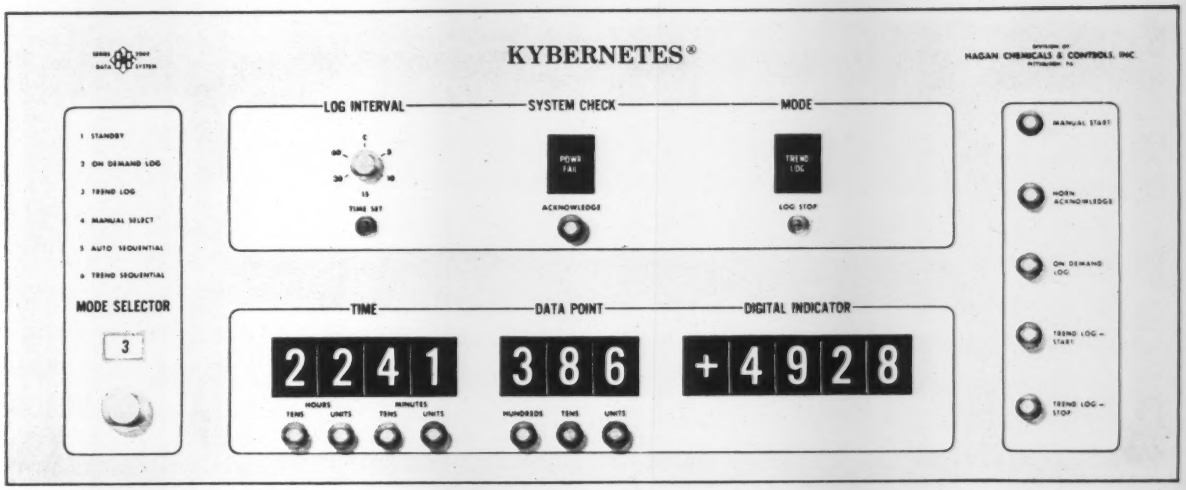
MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Stratford, Connecticut·
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

For more information circle **58** on inquiry card.

Hagan Chemicals & Controls, Inc., announces the

COMPLETELY NEW



Kybernetes Series 2000 Data Processing System

The new Kybernetes Series 2000 Data Processing System, utilizing solid state components, adds many data handling advances to the outstanding features of the original equipment. Here are some of the features the new Kybernetes system has to offer:

NEW FLEXIBILITY—Basic unit is a simple logging unit for recording process data on a log sheet or other output device. This basic system can be expanded easily, both in terms of the number of points scanned, and the complexity of the operations performed by the unit. For example these can be added as need develops: *Scanning for off-normal conditions—Printed or visual trend of selected variables—Computing and integrating—Automatic programming and optimum setting of control.*

NOTE—*Any* or *all* of these functions may be performed without interrupting any of the other functions. Off-normal scanning *always* proceeds uninterrupted.

OPTIMUM RELIABILITY—Fewer components, simplified design logic and solid state components add to the inherent reliability of the system. All parts have been selected for long life and easy maintenance.

MODULAR CONSTRUCTION simplifies extension of system. Each new function can be added by simply plugging-in appropriate module.

SELF-CHECKING CIRCUITS immediately signal malfunction in any area and spot the area with a warning light.

ACCURACY of 0.1% on all inputs, including non-linear types is achieved by eliminating marginal techniques and components, using the highest quality components and by the use of simplified design logic.

Flexible, accurate and reliable, the new Kybernetes Series 2000 Data Processing System offers many previously unattainable advantages. Designed for maximum usefulness with minimum investment, *the new Kybernetes system permits the addition of functions as needed, including complete computer control.* A new brochure describes these advantages in detail. Write today for your copy; ask for Bulletin MSP-161.

HAGAN CHEMICALS & CONTROLS, INC.

DIVISIONS: CALGON COMPANY, HALL LABORATORIES

HAGAN BUILDING, PITTSBURGH 30, PA.
In Canada: Hagan Corporation (Canada) Limited, Toronto
European Division: Via Flumendosa No. 13, Milano, Italy

For more information circle **59** on inquiry card.

What a build!

... solid state components

in New Fenwal

Temperature Controller combine precision with extra reliability

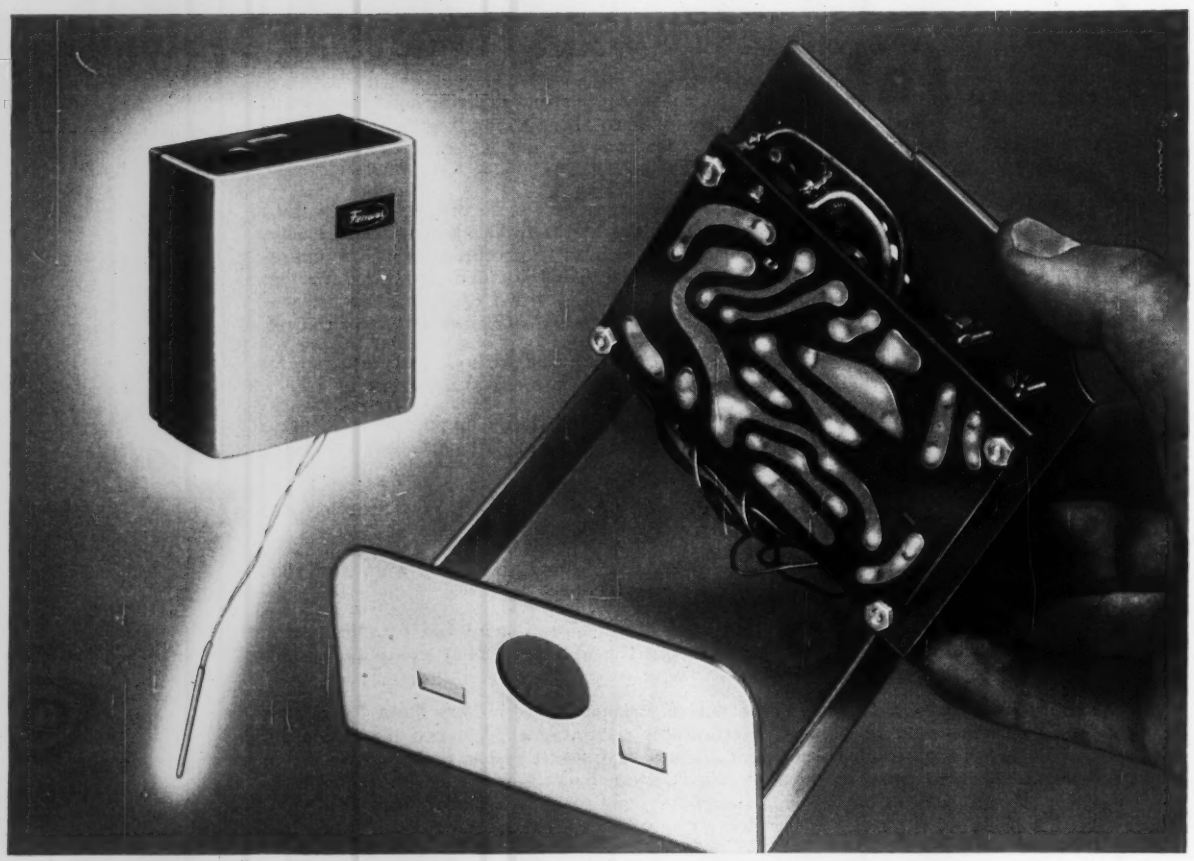
Here's a new, low-cost temperature controller that's really built "solid": thermistor sensing element, printed circuit, transistors. *No wonder the Fenwal 535 Temperature Controller provides high precision, trouble-free operation and long life!*

The Model 535's solid state components pay off in simplicity and dependability. The thermistor sensor mounts up to hundreds of feet from the controller using uncompensated electric wiring; has virtually limitless life; feeds into a rugged transistor amplifier. *No moving parts . . . nothing to wear out!*

The Model 535 is the latest advance in the low-cost line of Fenwal Temperature Controllers specifically developed to fully exploit the advantages ... rapid response, compact size, reliability . . . of solid state components. *And Fenwal, alone, has integrated production of both controllers and thermistors.*

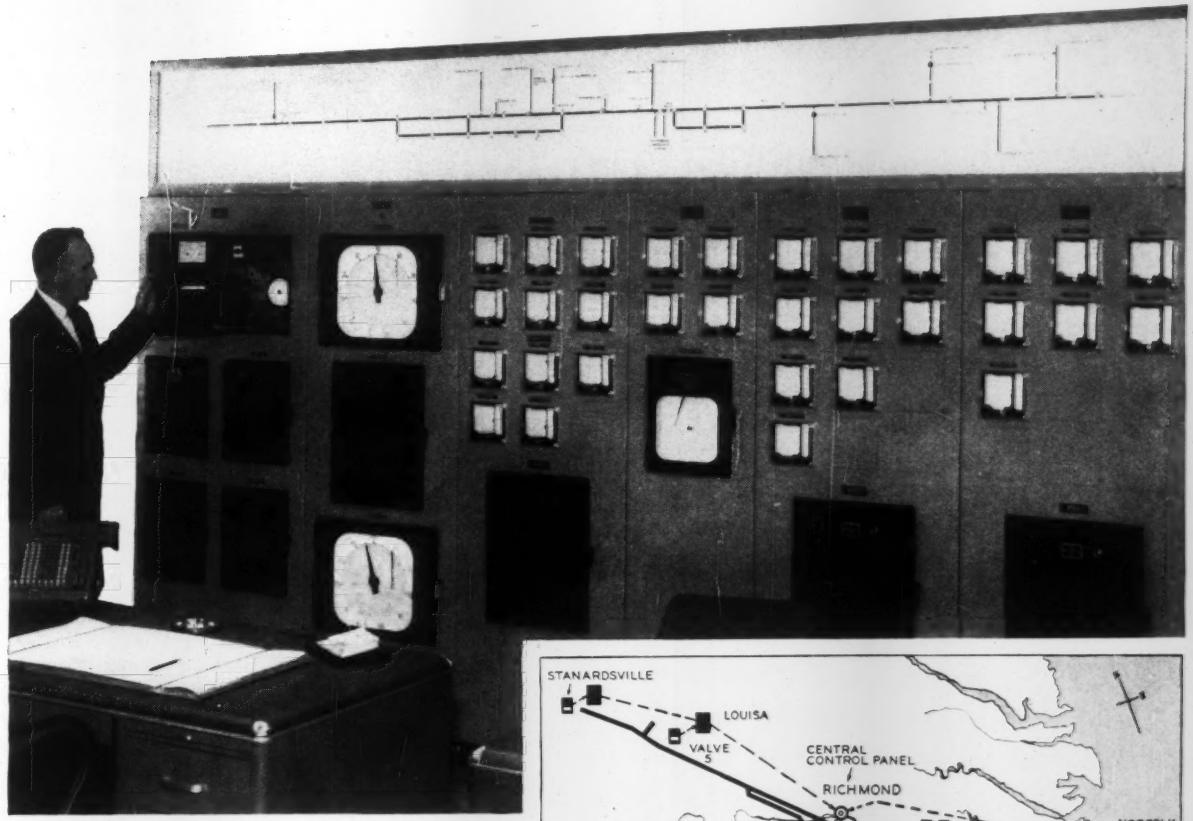
Use the Fenwal Model 535 Controller for fast response and close control of temperatures from −25°F to +600°F in plastics, packaging, or other critical applications. Get full details from a Fenwal Sales Engineer or write for catalog. Fenwal Incorporated, 364 Pleasant Street, Ashland, Mass.

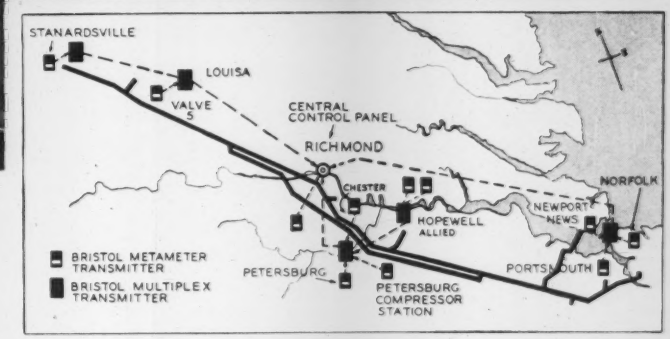
Single point Model 535 Fenwal Temperature Controller has 2°F setting accuracy and sensitive operating differentials from 0.4°F to 1.2°F. Current capacity: 5 amps. 115 volts AC — 10 amp. model later in 1959.



ANOTHER EXAMPLE OF HOW **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

For more information circle **60** on inquiry card.





Schematic in top panel shows 300-mile pipeline system controlled by 31 Bristol miniatures, 13 full-sized Bristol instruments below. Map shows system ranging from Stanardsville in Northwest to Norfolk in Southeast Virginia.

Dispatcher's-eye view of a complex 300-mile pipeline system

From this panel of Bristol Metameter* telemeters, dispatchers at the Commonwealth Natural Gas Corporation of Richmond, Va., monitor natural gas supplied to the City of Richmond, The Petersburg and Hopewell Gas Company, The Virginia Electric & Power Company in Norfolk and Newport News, The Portsmouth Gas Company and several large industrial users, and also control the operations of the corporation's compressor station near Petersburg.

In addition, a computing system calculates, records and integrates the flow of gas and automatically corrects for pressure, temperature, specific gravity and supercompressibility so as to aid the dispatcher in approaching but not exceeding the demand figure. Flows, pressures, temperatures and specific gravity are continuously telemetered from critical points along the line. This Bristol telemetering system incorporates both direct wire and multiplexing systems, and uses both full-sized and miniature instruments. Bristol's complete line enables users to select the most economical and efficient unit for each specific application.

Advanced Bristol telemetering and centralized control increases reliability, steps up efficiency and reduces operational costs on any gas system. To find out how, write: The Bristol Company, 113 Bristol Road, Waterbury 20, Conn. B-36

USES NEW BRISTOL MINIATURE METAMETER* TELEMETER RECEIVERS

The miniature Metameter Receiver permits centralized recording and indicating of a large number of variables in a minimum space—presents a uniform, pleasing, easy-to-read panel appearance—measures only 5" x 5⅛", records on a 3" chart (indicating model has 9" scale), fits into 4 9/16" square panel cutout.

*T.M. Reg. U.S. Pat. Off.

BRISTOL *TRAIL-BLAZERS IN PROCESS AUTOMATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **61** on inquiry card.

CRESCENT

POLYETHYLENE INSTRUMENT TUBING

Costs Less—Is Easier To Install

SIX DIFFERENT TYPES TO MEET YOUR SPECIFIC NEED

CRESCENT POLYETHYLENE MULTITUBE is 2 to 37 precision Polyethylene tubes *spirally cabled* together for greatest flexibility. The tubing assembly is protected against mechanical injury by an interlocked galvanized steel armor, Polyvinyl Chloride sheath, or other sheaths, as below.

CRESCENT POLYETHYLENE PRECISION INSTRUMENT TUBING

TYPE P is manufactured from the best high molecular weight virgin Polyethylene compound and TYPE XP of high modulus virgin Polyethylene compound selected for their superior resistance to environmental stress cracking and aging. Extensive research, improved manufacturing methods and rigid test standards have developed CRESCENT Polyethylene tubing to its present level of highest quality. It is furnished as single tubing in ¼", ⅜" and ½" sizes in up to eight bright colors. It is used exclusively in manufacturing CRESCENT POLYETHYLENE MULTITUBE in types as follows:

STANDARD TYPES

TYPE PA—Interlocked metallic armor provides complete mechanical protection.

TYPE PAT—Polyvinyl chloride sheath over the armor adds corrosion protection for the armor. Can be buried in the earth.

TYPE PT—PVC sheath gives limited mechanical protection. For use in troughs, trays or conduit.

SPECIAL SERVICE TYPES

TYPE XPT-U—Extra heavy PVC sheath over high modulus TYPE XP tubing permits direct burial, or use above ground where subject to moderate abuse.

TYPE XPT-F—Same as XPT-U with heavy asbestos braid and outer PVC sheath. Provides time delay in event of flash fire.

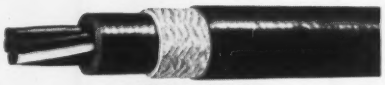
TYPE XPT-FA—Same as XPT-U with heavy asbestos braid and interlocked metallic armor. Provides complete mechanical protection, as well as time delay in event of flash fire.

TYPE PA

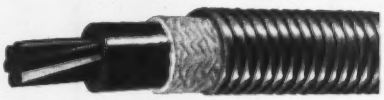
TYPE PAT

TYPE PT

TYPE XPT-U



TYPE XPT-F



TYPE XPT-FA

Write for complete information on these types, as well as types employing copper or aluminum tubing.

Ask for new bulletin No. 458-A

CRESCENT INSULATED WIRE & CABLE CO., INC.

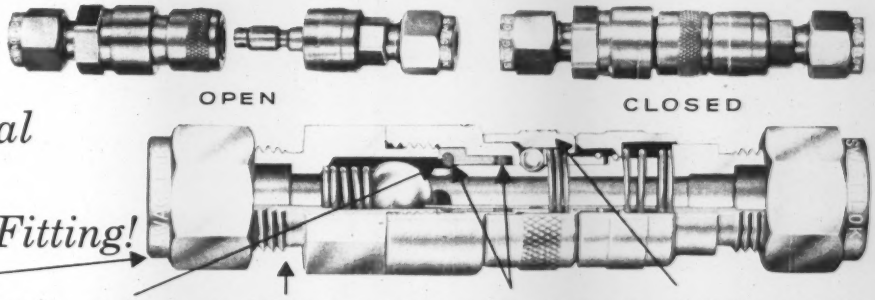
TRENTON, NEW JERSEY

For more information circle **62** on inquiry card.

What's the secret of this fast, positive-seal fitting?

Swagelok Quick-Connect Fitting Installation in Boeing Airplane Company, Seattle, Wash., Test Facilities for Boeing 707 Jet Stratoliner.

Here's the secret of this fast, positive-seal Swagelok Quick-Connect Fitting!



1. Swagelok Quick-Connects with single end or double end shut off for tube to pipe, tube to tube, bulkhead tube to tube applications are available in brass and stainless steel in sizes for ¼" and ⅜" O. D. tubing.

2. Flow resumed instantly and vacuum tight seal assured when connection is made.

3. Light, compact, streamlined design. Occupies little space. For use with portable equipment, and bulkhead or panel applications.

4. Instant-acting seals completely prevent loss of pressure when fitting is disconnected.

5. No twisting, turning or wrench action necessary. Easy straight-line finger tip pull or push action for instant connecting or disconnecting.

In the Boeing Airplane Company photo shown above, the tubes are instrumentation pressure lines running from the large jet engines on test stands to the patch board, where the lines are coupled into measuring devices.

The Boeing Airplane Company adopted this positive Swagelok Quick-Connect Fitting to simplify test installations, and substantially cut down test set-up time. Both ends of the many pressure lines are Swagelok-equipped. Previously, engineers used a screw-type fitting which required a wrench and valuable time-consuming operations to tighten and remove.

Swagelok engineers are equipped with experience, ability, and a wide range of tube fittings designed to meet your individual problems. Quick delivery of Swagelok tube fittings from local distributor stocks.

Swagelok® TUBE FITTINGS

CRAWFORD FITTING COMPANY
884 East 140th Street, Cleveland 10, Ohio
Crawford Fittings (Canada) Ltd., Niagara Falls, Canada

For more information circle **63** on inquiry card.

connect with CANNON PLUGS

27,000 kinds to choose from! If we don't have what you want, — we'll make it for you.

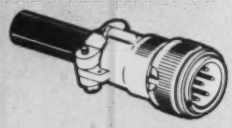
Largest facilities in the world for plug research, development and manufacturing

USE for AIRCRAFT and ELECTRONIC INSTRUMENTS

TYPICAL DESIGNS

MS, MS-A, MS-B, MS-C . . . Conforming to Specification MIL-C-5015C. 15 insert diameters and 260 contact layouts. 6 shell styles, MS3100 to MS3108 with all accessories. Also (MS) F.

for VIBRATION RESISTANCE and MOISTURE-PROOF applications

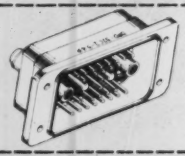


MS-E SERIES . . . environment resisting. Meets Specification MIL-C-5015C. Resilient inserts. Integral cable clamp. New grounding lugs. Interfacial sealing, improved grommet and new grommet follower.

for GENERAL CIRCUITRY and QUICK DISCONNECT in more rugged applications

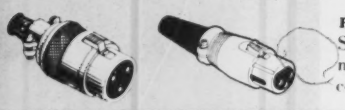
K, RK SERIES . . . SPECIAL ACME THREAD. The All-Purpose Series. Conduit and cable clamp entry types. 1 to 82 contacts in 213 different contact layouts. 10-, 15-, 30-, 40-, 60-, 80-, 115-, and 200-amp. silver-plated contacts. High quality phenolic, melamine, and formica insulators. Cadmium-plated aluminum alloy shells.

for UNIT-PLUG-IN applications . . .



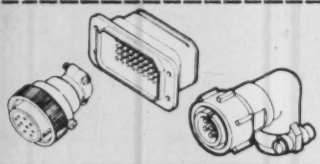
DP, DPB, DPD, DPD2, DPD2R, DPJ, AND DPS SERIES . . . Rack/panel/chassis. With and without shells; coaxial and high voltage contacts. Permit quick disconnect, interchange, replacement, testing and inspection of assemblies and sub-assemblies.

for AUDIO and LOW LEVEL circuits



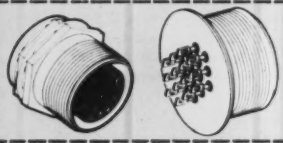
P, XLR, XL, XK, O, UA, BRS SERIES . . . many shell styles and insert layouts. Straight and angle 90° plugs. Latch-lock types. Wall-mounting, panel, lock-nut mounting, and adapter receptacles, single- and two-gang. 10- to 30-amp. contacts, coaxials. UA Series features 3 gold-plated contacts.

for RADIO and SUB-MINIATURE applications



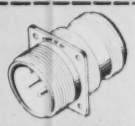
D, MC, DPA, DPX, AND K MINIATURES . . . miniatures and sub-miniatures designed for amplifiers, miniature indicators, computer circuits, telemetering equipment, small pre-amps, and general instrumentation where space is limited and current requirements are generally not over 5 amperes. Variety of shell styles, junction shell, and insert arrangements. 3 to 50 contacts, plus coaxials.

for HERMETICALLY SEALED applications



GS (MS TYPE), KH, RKH, DAH, BFH, TBFH, DBH, KH30 . . . with steel shells and contacts to withstand high pressures from within or without. Insulation is a glass material, fused under high temperature to shell and contacts, thus forming a hermetic seal.

for HIGH TEMPERATURE and firewall applications



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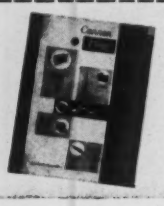

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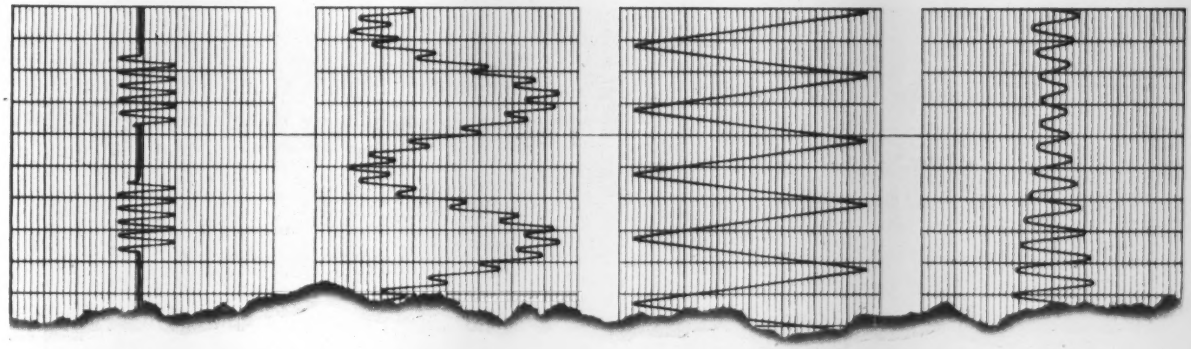

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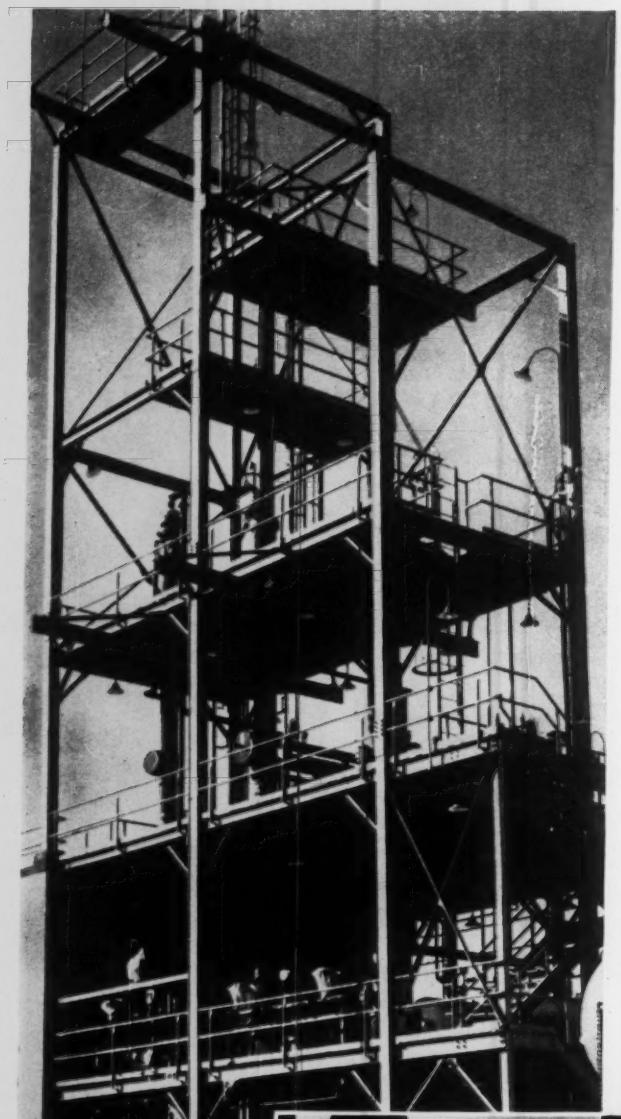

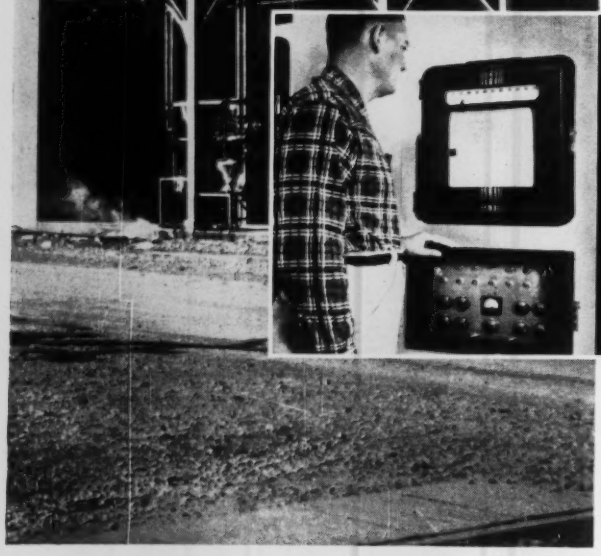

In the control room of Pennsalt's Isotron plant, a process operator checks component variations on a Chromomax Analyzer as a guide to resetting control points.

New

CHROMOMAX*

helps Pennsalt boost product quality

For more than six months, Pennsalt Chemicals Corporation at Calvert City, Ky. has based control of its Isotron plant on Chromomax data. Component concentrations as low as 0.01% are detected and measured by this highly sensitive L&N Chromomax Gas Chromatography Analyzer. It enables Pennsalt's operator to monitor impurity levels every 10 minutes . . . to make any necessary control adjustments. The result: the refrigerants and aerosol propellents produced have a purity of more than 99%.

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If you, too, have a process stream measuring problem, let L&N's versatile Chromomax Analyzer solve it . . . economically . . . dependably. If required, your Chromomax can be equipped with dual column switching or electronic integration.

Check with your nearest L&N Office for application details or write to Leeds & Northrup Company, 4955 Stenton Ave., Phila. 44, Pa. for information.

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editorial

IRE Show Report

SIXTY THOUSAND registrants; 17,000 pieces of exhibited apparatus; 950 commercial exhibits; 275 technical papers—all the statistics of the IRE Show are large. Such size offers a challenge to the man who would separate the significant and important from the trivial, and who would interpret the event in terms of its significance to society.

The electronics industry is obviously fat and happy—as only a reliable multibillion-dollar customer can make an industry. The farmers of America have parity: the electronics industry has "defense." Fortunately the multibillion-dollar expenditures contribute to health and welfare, if indirectly, as evidenced by 10 papers on various aspects of medical electronics, and the following few exhibited medical equipments: A *tissue resistance monitor* for the psychology lab (Airborne Instruments Lab), *cardialyzer* for heart sound analysis (Kay Electric Co.); *blood pressure manometers* (Technitrol Engineering); and an automatic *bacteria colony counter* (Telechrome Mfg.).

Interest in *adaptive control systems* is high, even though the theory and practice of this field is in its infancy. There were five papers in this field.

Our annual award for "outstanding innovation" goes to a device that adds a new dimension to measurements, which previously have been either indicated or recorded. Cubic Corporation exhibited a "talking voltmeter." A feminine voice on tape reads out the reading, complete with decimal point. This technique, with possible application wherever the eye cannot be taken from the point of interest (as in surgery, flight, perhaps even driving, eventually), has much possible significance—a true new dimension in measurement!

Data, Computing and Recording News

Of particular significance to the field of computing is Trio's *Rodiac*, a 2-dimensional potentiometer that can solve 3-dimensional equations—i.e., z = F (x,y). The "pot" has two shafts. Main shaft rotates a disc on which a family of functions is placed; second shaft moves a contact radially across disc so as to select any one curve of function. Result: Rodiac can solve any problem that a 3-d cam can solve; can generate functions for computers and simulation, etc.

Young field of growing importance is coupling between analog and digital computers. Electronic Associates exhibited an *analog-digital computer linkage* system.

We were disappointed with the reduced emphasis in *analog computation*, with only two exhibitors, Electronic Associates and Mid-Century. Latter revealed new *repetitive operation feature* which gives 60 solutions per-second.

Shaft position encoders of many different styles and models were exhibited by Datex, Giannini.

In growing field of digital readout, Baird-Atomic unveiled new *Digitron*, a 10-digit direct readout cold-cathode tube, with a large letter upright in tube.

Laboratory for Electronics exhibited a *digital generator and viewer* that converts coded data into visual messages on a C-R tube; also a new *magnetic file drum* for low cost high-density storage.

New Packard-Bell *magnetic modules* can drive 50 core stages from 1 drive transistor.

New 20-channel *data logging system* (CANDU 1) of Franklin Electronics logs 4 channels per second; has 5-microvolt sensitivity.

An outstanding recording innovation was new 670 *x-y recorder* of Sanborn, using *optical technique* and direct printout with ultraviolet-sensitive paper, giving response to 130 cps.

New magnetic tape unit for use with the RW-300 computer of Thompson-Ramo Wooldridge converts computer into complete on-line data reduction system.

New Industrial Instruments

Industrial Division of Daystrom revealed a new *wire gage* accurate to 1 part in 1000.

Precision tachometer (0-12,000 rpm) of AMF has 1.25% full-scale accuracy.

The *printed-circuit motor* of Photocircuits attracted great interest. Said to be "first major change in motor design in 50 years," it uses a printed circuit armature in the field of sets of magnets arranged on the periphery of the circular housing. The low inertia and linear speed-torque curve of the armature should give it fine servo characteristics (Photocircuits is still seeking licensees for this important motor).

Tiny controller of International Instruments is small p-m m-c movement with transistor oscillator. Metal shield attached to pointer passes between two coupled coils to decrease signal, operating sensitive relay.

New Electrical and Electronic Instruments

New *instrument calibration console* of Radio Frequency Laboratories is secondary standard for calibration of d-c electrical instruments to 0.1%, a-c to 0.3%; Sensitive Research Instrument showed new Model LTC *laboratory standard test console*, featuring 0.05% accuracy on all ranges; *Voltage reference source* of Epsco has 0.01% absolute accuracy, thus providing secondary standard accuracy.

Rawson introduced a new *r-f voltmeter* (thermocouple type) with 1% accuracy from dc to 100 Mc.

Serious problem is checking of transistors without removing them from circuit. Sierra Electronic Corp. unveiled a *transistor tester* that can test transistor beta in the circuit.

New DuMont *oscilloscope* Type 410 has response from dc to 50 Mc.

Interest in maser and parametric amplifiers for low-noise microwave amplification seems high.

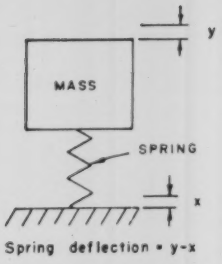


FIG. 1. MASS AND SPRING comprise basic seismic system.

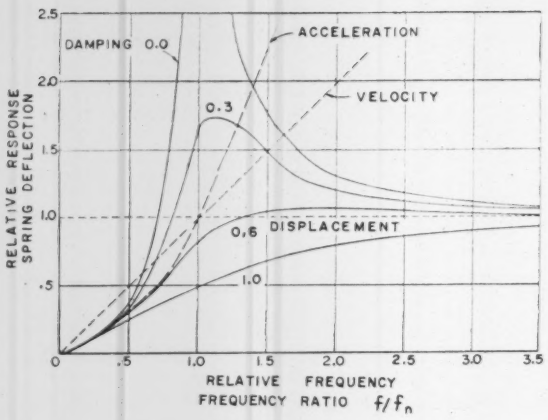


FIG. 2. RELATIVE RESPONSE (spring deflection/base motion) versus relative frequency (f/f_n).

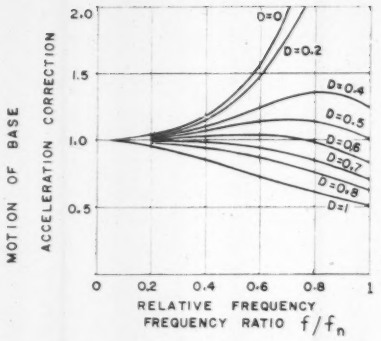


FIG. 3. NORMALIZED CURVES showing acceleration correction (difference between relative response and the acceleration curve) versus relative frequency.

Fundamentals of Restrained Motion

THE MOTION of a spring-mass system (Fig. 1) illustrates fundamentals of response that are basic to many fields of instrumentation—galvanometry, accelerometry, vibration measurement, stress analysis, resonance, and many others. A similar response, differing only in units, is vital to the fields of electronics, including oscillation, resonance, and filter theory. Thus the response of the spring-mass system has important instrumentation implications; all workers should be intimately familiar with the response.

The input to the spring-mass system is movement of the base. The problem is to measure the motion of the base (that is, its displacement, velocity and/or acceleration), by using the response of the mass (spring deflection). Note that the *variable* is base displacement; however, the *measurable* is mass displacement relative to the base (spring deflection).

If mass displacement were plotted against base displacement, a family of curves would be required for every frequency, for every degree of damping, and for every increment of base motion. This would be cumbersome.

The response can be shown for all base motions and for all frequencies by *normalizing* the response and frequency curves—that is, by plotting the *ratio* of mass to base movement (as one axis) against the *ratio* of signal frequency to natural frequency of the system (as a second axis). This makes the same curve applicable to any given system.

The normalized response curve is shown in solid lines in Fig. 2. The *relative response* is actually the ratio of spring deflection to base movement or $(y - x)/x$, where y is mass displacement and x is base displacement. The *relative frequency* is f/f_n, where f is the frequency of the base motion and f_n is the natural frequency of the mass-spring combination. This is conventional normalizing technique.

The dotted curves in Fig. 2 refer to the displacement, velocity, and acceleration *of the base*, which are the inputs (the variables to be measured). The displacement curve is horizontal because the base is vibrated sinusoidally at constant amplitude; the velocity curve is linear because the velocity of a body vibrated sinusoidally at constant amplitude is linear with frequency; the acceleration curve shows that the acceleration of the body varies as the square of the frequency, as will be seen.

In order to use the mass-spring system as an accelerometer, the response curve should have the same shape as the acceleration curve. It does only up to about 0.7 times natural frequency for a system with 0.6 critical damping. This is the *accelerometer region* of a seismic system.

The response curve is shaped like the velocity curve (linear) only up to about 1.5 times the natural frequency for a critically damped system. Thus a critically-damped seismic system could be used to measure velocity in this region.

In order to measure *displacement*, the relative response curve should be horizontal—that is, the mass should stand still while the base moves. This occurs at frequencies above the natural frequency of the mass-spring system, and the seismic system can be used to measure displacement of the base in this region. This is the *displacement region* of the seismic system.

Note that the same system measures displacement, velocity or acceleration, depending on frequency. Above its natural frequency the system measures displacement; below it, it measures acceleration.

Relationships between Displacement, Velocity, Acceleration and Frequency

A sinusoidal displacement (x) can be expressed as

$$x = A \sin(\omega)t$$

where A = maximum amplitude, $\omega = 2\pi f$, f = frequency of motion.

Velocity of the body can be defined as dx/dt:

$$dx/dt = (\omega)A \cos(\omega)t$$

The acceleration of the body can be defined as d^2x/dt^2:

$$d^2x/dt^2 = -(\omega)^2 A \sin(\omega)t$$

Hence the maximum acceleration (a) $= \omega^2 A$.

It is customary to express the acceleration in terms of g's, or the equivalent number of accelerations equal to the acceleration of gravity. As g = 981 cm/sec/sec or 386 inches/sec/sec, the values in Table 1 show the g value in each system, for any given frequency and amplitude of displacement. Note that amplitude is usually expressed in terms of peak-to-peak displacement, or double amplitude (DA):

$$a = \omega^2 A = 4\pi^2 f^2 A = 2\pi^2 f^2 (DA)$$

A (expressed in g's) $= \omega^2 A/g =$ g value

TABLE 1—ACCELERATION IN TERMS OF AMPLITUDE AND FREQUENCY

g	981 cm/sec/sec	386 in/sec/sec	32.16 ft/sec/sec
DA	double amplitude expressed in cm	double amplitude expressed in inches	double amplitude expressed in ft
f	cps	cps	cps
(g value)	$2\pi^2f^2(DA)/981$ $=0.0201(DA)f^2$	$2\pi^2f^2(DA)/386$ $=0.0511(DA)f^2$	$2\pi^2f^2(DA)/32.16$ $=0.6133\ (DA)f^2$

Correction for Frequency and Damping

It has been shown that the mass-spring system "measures" acceleration below its natural frequency, and displacement above its natural frequency. But errors exist at any frequency owing to frequency and resonance effect.

Sometimes it is desired to determine displacement below the natural frequency, or to apply a correction factor to the acceleration reading for high accuracy. Also, it sometimes is desired to measure the acceleration above the natural frequency of the system, or to apply a correction to a displacement measured in this region.

This can be done directly for displacement readings by referring to the relative response curves, as will be shown. For acceleration correction, a mathematical correction can be made, or a correction can be made by referring to Fig. 3, which is a curve of the ratio of the relative response curves of Fig. 2 at any point to the desired acceleration curve at that point. This gives an acceleration correction factor directly.

Example 1: Correct an accelerometer reading taken with following data:

1. **Accelerometer reading = 4.0 ft/sec²**
2. **Accelerometer damping = 0.4**
3. **Accelerometer natural frequency = 5 cps**
4. **Frequency of signal = 3.5 cps**

From 3 and 4, the frequency ratio is 3.5/5, or 0.7

From Fig. 3, at D = 0.4 and frequency ratio = 0.7, the accelerometer correction is 1.3. In other words, the mass moved 1.3 times too far. Hence the actual reading should be

$$a = 4.0/1.3 = 3 \text{ ft/sec}^2 = 0.096 \text{ g}$$

Example 2: Correct a displacement measurement above f_n:

1. **Measured displacement = 0.12 inch**
2. **Measured frequency f = 10 cps**
3. **Frequency ratio = 2**
4. **Accelerometer damping = 0.3**

From Fig. 2, at frequency ratio of 2 and D = 0.3, it is seen that the mass moved 1.2 times too far.

Hence correct displacement = 0.12/1.2 = 0.10 inch.

Example 3: Correct displacement below f_n:

1. **Displacement reading = 0.12 inch**
2. **Measured frequency = 3.5 cps**
3. **Frequency ratio = 0.7**
4. **Damping = 0.6**

Referring to Fig. 2, at D = 0.6 and frequency ratio = 0.7, the mass is seen to have moved only 0.5 times as far as it should have.

Hence correct reading = 0.12/0.5 = 0.24 inch.

Example 4: Find acceleration above f_n:

1. **Accelerometer reading = 0.12 inch (at this frequency the instrument really reads a displacement).**
2. **Measured frequency = 10 cps**
3. **Frequency ratio = 2**
4. **Damping = 0.3**

First we correct the displacement reading as in example 2, to find that A = 0.10 inch.

As the correct displacement is known, the acceleration is found from the equation:

$$d^2x/dt^2 = \omega^2 A = (2\pi f)^2 A$$
$$= (2 \times 3.14 \times 10)^2 (0.10)$$
$$= 394.38 \text{ in/sec}^2$$
$$= 1.02 \text{ g}$$

Slide Rule

A slide-rule-type "Vibration Computer" has been developed which gives the displacement-frequency-acceleration relations directly, both for linear and angular movements (available from MB Mfg. Co.)

The angular scales represent the formulas $\alpha = 19.74^2\theta$ and $v_a = \pi f\theta$ where α = vector torsional acceleration in radians/sec², f = frequency in cps, θ = peak-to-peak angular amplitude in radians, and v_a = vector sinusoidal velocity in torsion in radians/sec. The computer will then give magnitude of θ for any α, and v_a for any θ at a given f.

The reverse side of the rule covers the several basic calculations that are involved in *random motion* work, a field of vibration testing that is growing in importance. The upper scales represent the expression $A_r = \sqrt{BG_o}$ where rms acceleration (A_r in g's) can be obtained for random motion as a function of frequency bandwidth (B in cps) and a constant acceleration density (G_o in g²/cps). Total rms acceleration (A_t) can be obtained.

Displacement

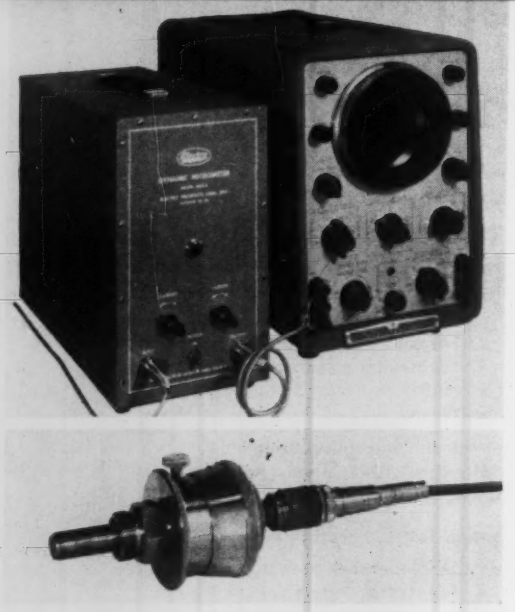


FIG. 1. DISPLACEMENT DISTANCE between object and probe can be measured by vertical deflection of scope trace. Resolution is 0.0001". (Courtesy Electro Products Labs.)

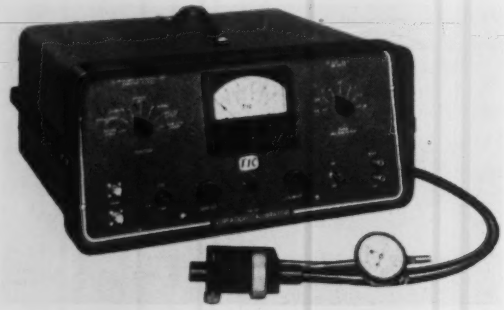


FIG. 2A. NON-CONTACTING PROBE measures displacement from 10 to 20,000 cps by changes in mutual inductance. (Courtesy Tel-Instrument Electronics Corp.)

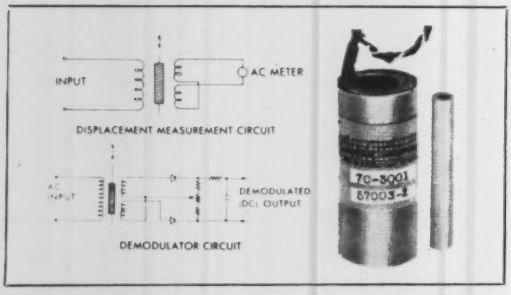


FIG. 2B. LVDT is common and versatile displacement indicator transducer, but requires contact between object and core. Advantages include low cost and high sensitivity (above 20 mv per volt excitation per 0.001" movement. (Courtesy International Resistance Co.)

A VIBRATION METER is an instrument that indicates displacement, velocity *and* acceleration. Although a simple displacement indicator can be used to detect vibratory motion of a part, it should not be called a vibration meter; this term should be reserved for the instrument that indicates displacement, velocity *and* acceleration. A displacement indicator should be called that and that alone. This material discusses displacement indicators.

Reactance

Fig. 1 shows a "dynamic micrometer" based on change in reactance of a sensing coil when its high-frequency field encounters an external metal body. This change in amplitude of carrier voltage is amplified to give an eventual displacement sensitivity of 0.0001". Response is from 0 to over 200,000 cps.

Mutual Inductance

Fig. 2A shows a displacement indicator designed as a "Vibration Calibrator." The pickup comprises two coils, one of which is excited at 2.5 Mc. The mutual inductance of the coils, and hence the output of the second coil, depends on the distance between the probe face and the reference surface. If the reference surface vibrates, the output contains an a-c component proportional to the amplitude of the vibration.

Fig. 2B shows the versatile LVDT displacement transducer in which core position determines the coupling between primary and double-secondary windings. Advantages include low cost and high sensitivity.

Variable Reluctance

Fig. 3 shows a unit which uses a velocity-type inductive pickup to measure displacement amplitude. Frequency range (3%) is 12 to 1000 cps.

Capacitance Type

Fig. 4 shows the "Delta" displacement indicator based on capacitance change. This general-purpose capacitance-type gage can be used for vibratory displacement measurements. The non-contact feature of capacitance measurement offers the advantage of almost zero coercive force. It is based on use of the "T-42 Ionization Transducer," a device that converts minute change in capacitance into large proportional

Measurement

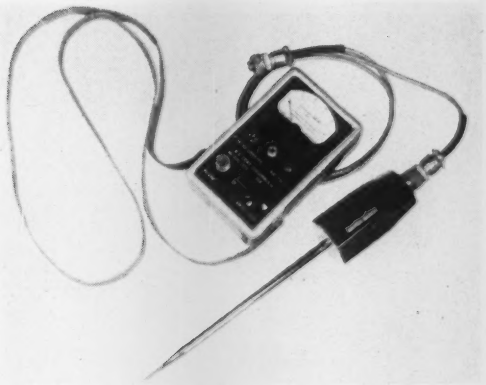


FIG. 3. IRD MODEL 305 Vibration Meter is displacement indicator using velocity-sensitive probe. (Courtesy International Research & Development Corp.)

voltage signals, without the instability or extensive circuitry usually associated with capacitance measurements. A capacitance change of 1-50 $\mu\mu$f can be converted into $\pm$30 v; the frequency response (3 db) is dc-1500 cps with 18" probe cable. Zero drift is $\pm$15 mv in 24 hrs; stability is better than 0.1%.

Direct Linkage

Fig. 5 shows a contact-type instrument that records the displacement of the probe directly on a 1" chart.

Resistance

The strain gage is a resistance element that is widely used to study impacts and vibration. Although not used for calibrating accelerometers, it is widely used for structural displacement. It is significant that the now universally used bonded-filament strain gage first saw the light of day in connection with an impact problem. Clark and Datwyler at California Institute of Technology were engaged in a study of elastic and plastic properties of metals under conditions of very high-speed loading (impact). They use a pendulum impact tester to break tensile specimens and, after a prolonged search for a measuring tool, Simmons (also of Cal. Tech) conceived the principle of a bonded-filament gage, using a length of constantan wire bonded with Glyptal cement. This lead to the first truly successful attempt to measure the strains and forces occurring under extremely rapid loading rates.

Since that time the use of the bonded-filament gage to measure impact stresses and strains has become common practice. For instance, studies have been made of steam forging hammers, machine gun and field gun stresses and reactions, detonation pressures in gasoline engines, pressures and thrust reactions of solid propellant rockets (the smaller sizes of which approach impact speeds), water hammer in pipe lines and penstocks, and a host of other problems. There seems almost no practical limit to the rate of strain which these gages can handle since their gage lengths can be as short as 1/32", which is small relative to the speed of wave propagation in most engineering materials.

As compared with problems of impact testing, the bonded-filament strain gage has a comparatively easy and very broad application to the *vibration field*. Used to measure vibratory stresses and strains, tor-

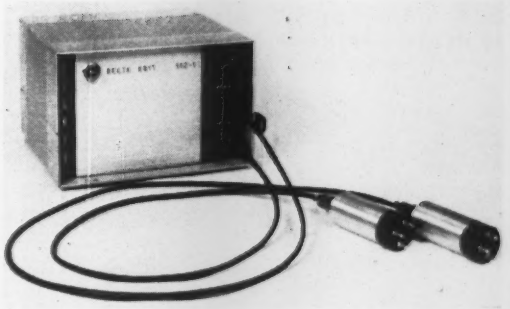


FIG. 4. DELTA UNIT uses capacitive element for sensing displacement. (Courtesy The Decker Corp.)

FIG. 5. CONTACT PROBE records displacement directly on 1" chart. (Courtesy The Korfund Co.)

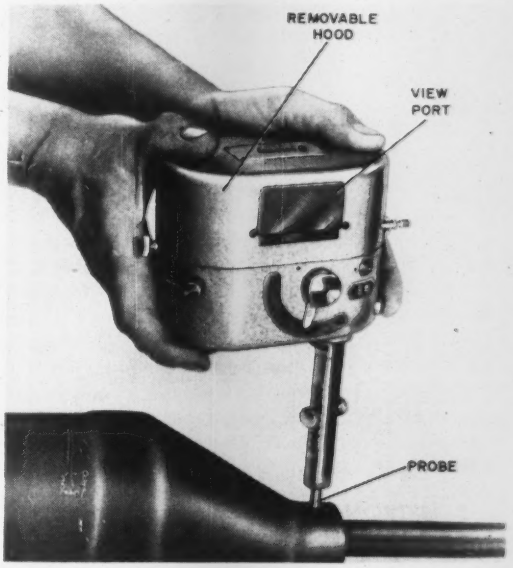


FIG. 6. STRAIN GAGES on propeller blades reveal stability when blade tips are subjected to vibration above sonic speeds. (Courtesy Baldwin-Lima-Hamilton Corp.)

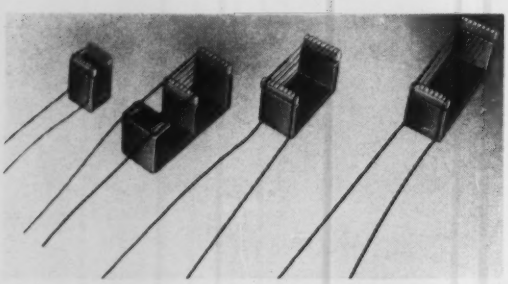


FIG. 7. STRAIN GAGES with detachable holding frame are easy to use, can be used at high temperatures. (Courtesy Waldale Research Co.)

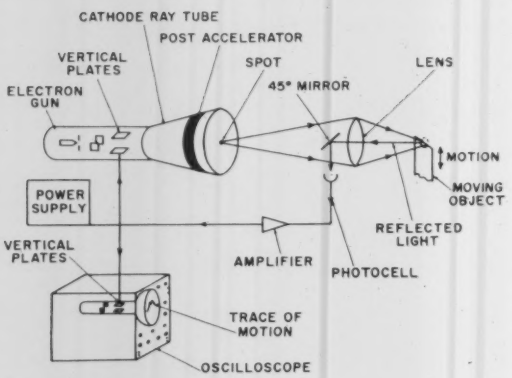


FIG. 8. OPTRON USES "captured-spot" principle to measure amplitude and frequency of vibration. (Courtesy Optronic Co.)

sional and axial forces, bending action, etc., the gage has been employed at frequencies from zero to over 50,000 cps in routine test work.

Among the vibration applications are studies of torsional vibrations in shafts of ships and other powered rotating devices such as pumps and engines; vibrations in flight of aircraft and missiles (frequently telemetered to ground by radio); propellor vibrations (Fig. 6) both on the test stand and in the air; submarine and ship structural vibrations; automobile and railway vibrations in actual service; and many others.

Fig. 7 shows a strain-gage element attached to a frame. The frame is removed from the element after the gage is attached to the unit whose strain is to be measured. This construction is especially adaptable to high-temperature work.

Optical Technique

Fig. 8 shows the Optron, an optical device that uses "captured-spot" technique. The intense spot from the cathode-ray tube is projected by lens onto the edge of the moving object. Reflected light is picked up by a 45° mirror and directed to a photocell. The signal from the photocell drives the c-r tube spot *up* via the vertical-deflection plates.

When the spot moves up beyond the edge of the vibrating object, no light reaches the photocell and the spot is driven *down*. Thus the projected spot captures the edge of the moving object and travels with it. The driving signal (in the order of 100 to 300 volts) becomes exactly proportional to the motion of the object and can be applied directly to an oscilloscope or recorder.

The device can be calibrated dynamically by scanning a known displacement. It measures amplitude of vibration from 1 microinch to 10 inches, with frequency response from 0 to 100,000 cps. Accuracy is 0.1%—and the noncontact feature means zero loading of the moving object.

Acknowledgment

Background material on use of strain gages in impact and vibration analysis was prepared by Dr. Arthur C. Ruge. The comments of Mr. Alvin Kaufman are also acknowledged.

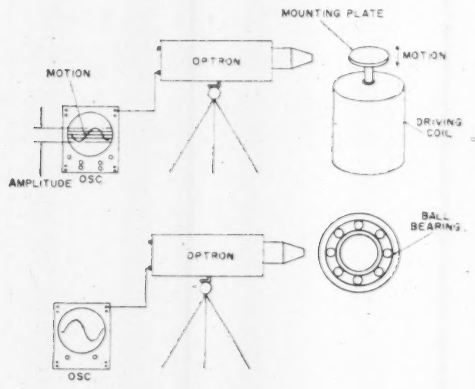


FIG. 9. USE OF OPTRON to measure amplitude and frequency of shake table (top) and runout of bearing race (bottom).

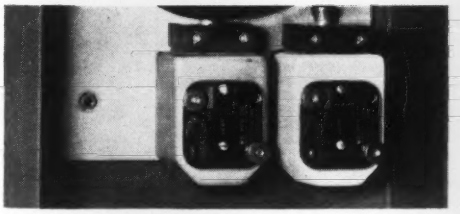


FIG. 1. VIBRATION PICKUP is velocity sensitive. (Courtesy MB Mfg. Co.)

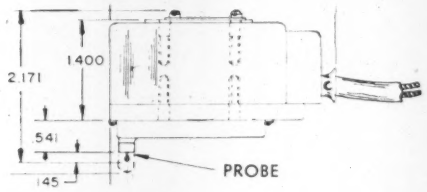


FIG. 2. PROBE type pickup.

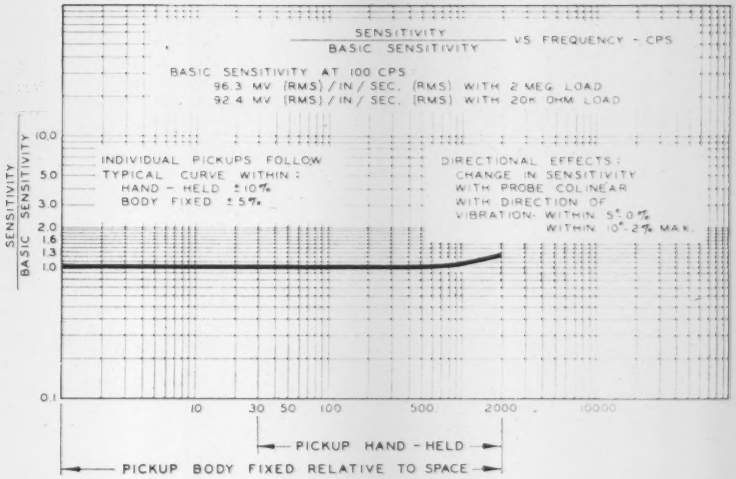


FIG. 3. RESPONSE of probe-type pickup. (Courtesy MB Mfg. Co.)

Velocity Pickups

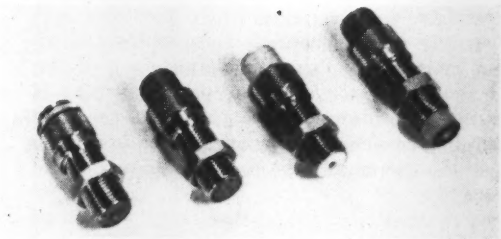


FIG. 4. MAGNETIC PICKUP develops signal proportional to velocity of nearby metal object. (Courtesy Electro Products Laboratories)

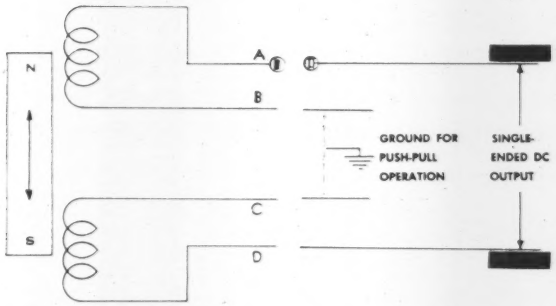


FIG. 5. VELOCITY transducer has magnet driven directly by shaft. (Courtesy Crescent Engineering & Research Co.)

VELOCITY-SENSITIVE PICKUPS are used in many vibration meters, and in some proximity indicators. The unit shown in Fig. 1 is simply a coil which is free to move in the magnetic field caused by Alnico magnets. The unit is attached to the vibrating member by machine screws, and any relative movement between coil and magnet produces a signal proportional to the velocity of the motion.

A similar unit (Fig. 2) couples the coil to the vibrating member by a probe, thus adding only 1 gram of mass to the vibrating structure. As shown by the response curve (Fig. 3), this unit, when held by hand, responds properly only above its natural frequency (f_n) because the case cannot respond fast and effectively stands still. As pickups are basically mass-spring elements, they respond as do all mass-spring units—that is, they respond properly (in this case, they read velocity) only above f_n. Below f_n they give an "acceleration-type" signal—that is, the signal is proportional to velocity squared.

Fig. 4 shows a magnetic pickup which translates the motion of ferrous objects into a measureable a-c voltage proportional to the rate of the object's movement. It comprises an Alnico magnet surrounded by a coil of wire. The external field is distorted by any external ferrous material, such as a gear tooth, and the unit is used commonly as a proximity detector.

Fig. 5 shows a velocity transducer comprising a cylindrical permanent magnet which induces voltages in two series-connected coils when it moves. The magnet is attached to a probe which is connected directly to the moving number. Sensitivity is 0.05 to 0.12 volt/inch/second, depending on model; displacement ranges are from 2" to 16" full scale.

ACCELEROMETERS

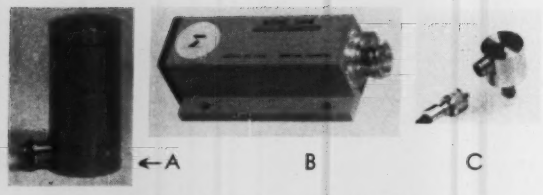


FIG. 1. PIEZOELECTRIC ACCELEROMETERS. A shows Kin Tel (Cohu) unit using ADP crystal. B shows Endevco unit with built-in amplifier, giving 300 mv/g output; C shows Gulton Glennite accelerometer usable to 525°F.

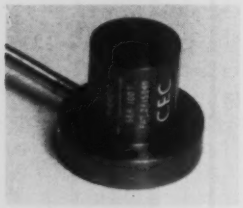
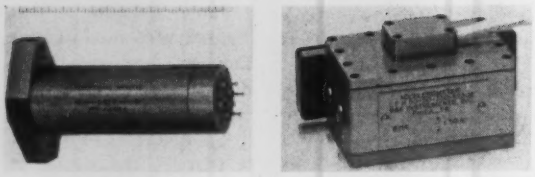


FIG. 2. ELECTROKINETIC ACCELEROMETER of Consolidated Electrodynamics Corp.



A B

FIG. 3. STRAIN-GAGE ACCELEROMETERS. A shows unbonded Statham unit; B shows B&F unit.

TABLE 1—CHARACTERISTICS OF THREE CRYSTAL ACCELEROMETERS

Model	Crystal Sensitivity mv/g	Crystal Capacity $\mu\mu f$	Dynamic Range g	Frequency Range cps	Accuracy (Linearity and Repeatability)	Weight oz.	Dimensions (dia x height) in.
M-1428	10	18	.001-2000	10-70,000	± 1% of Reading	1/6	11/32 x 11/16
M-191	41	110	.001-1000	10-27,000		1	5/8 x 1-5/16
M-198	125	180	.001- 500	10-15,000		4	1 x 2-3/16

Courtesy Kin Tel Div., Cohu Electronics

ACCELEROMETERS find extensive use measuring loads and stresses due to shock, vibration and change in velocity, and in motion analysis, as in inertial navigation.

An accelerometer is effectively a mass-spring unit, emphasizing the importance of the mass-spring response discussed previously. The word effectively is used because the mass can be the mass of the device itself or an added "seismic" mass*; the spring can be a physical spring or any device which develops a force proportional to its displacement.

Basically, the extension of the spring is measured and then related to acceleration. As has been described previously, this spring extension is proportional to acceleration only below the natural frequency of the system; above this frequency the spring extension is a measure of displacement, not acceleration. Thus the natural frequency of the accelerometer is a basic specification, determining the frequency range of the accelerometer.

Many techniques are used for detecting the "spring" extension. Two techniques—piezoelectric and electrokinetic—are self-generating, developing an emf internally. The others (with the exception of the gyro) are all passive elements that measure the spring extension directly or by an effective change in resistance, capacitance or inductance.

The gyroscopic accelerometer detects the force of acceleration of the "seismic" mass by use of the precession force of a gyro.

Piezoelectric

The crystal accelerometer uses the mass to exert a force directly on a piezoelectric crystal (Fig. 1). It is widely used because of its small size and wide frequency range. Accelerometers are available with g range from 0.001 to 40,000; frequency range from 3 to 70,000 cps. Its basic disadvantage is that it does not have d-c response—that is, it cannot measure a static constant acceleration. Typical characteristics are shown in Table 1.

*A comment is in order on the word seismic. This word means "referring to the earth." As one of the first uses of accelerometers was in seismology, the mass has been commonly referred to as a seismic mass even in accelerometers used for purposes other than seismology.

A survey of the ten basic types of accelerometers available commercially.

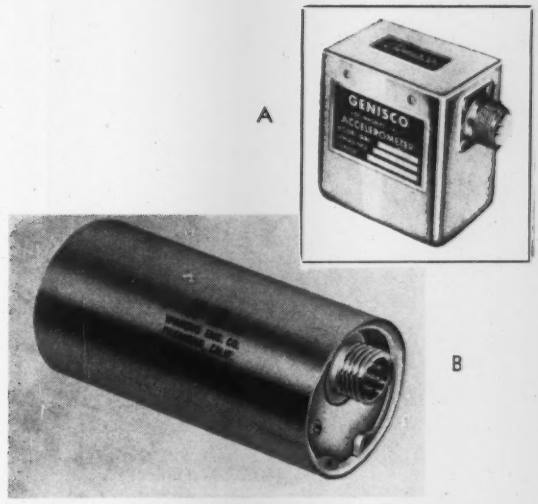


FIG. 4. VARIABLE INDUCTANCE ACCELEROMETERS. A shows Genisco GAL, excited at 400 to 5000 cps; B shows Wiancko unit, with 0-5 v d-c output (demodulated) for telemetering.

Electrokinetic

Electrokinetic devices (Fig. 2) generate electrical energy from the minute flow of a polar fluid passing through a ceramic disc. The polar fluid, acting as a seismic mass, is contained in a cylinder partitioned laterally by the ceramic disc and closed at both ends by flexible diaphragms. As vibratory acceleration or shock occurs, a minute amount of the polar fluid is forced through the porous ceramic disc. This creates an electrical output whose strength is proportional to instantaneous acceleration.

Electrokinetic devices respond to shock excitation as if they were many times critically damped. This means that these accelerometers will not ring (no natural frequency can be excited), will not be damaged by very high frequency, are virtually indestructible (the pickups themselves withstand overloads of 5000 g's) and will not "remember" shocks (sensing of a 1000-g step-function can be followed instants later by a 10-g sinusoidal acceleration, for example). Accelerometers are available for measuring from 0.01 to 1000 g; frequency range 3 to 30,000 cps.

Output from these accelerometers may be fed to galvanometers or other recording equipment by using suitable matching equipment, such as a cathode follower or high-input-impedance amplifier.

Strain Gage

The strain gage (Fig. 3) measures the spring displacement directly as a resistance change. It is widely used because of its accuracy, response from dc to 1500 cps, g range from 0.01 to 1000, and flexibility in application and excitation (dc or ac). Characteristics of a typical line are shown in Table 2.

Variable Inductance

This technique uses the movement of the mass to change the position of a core in a coil, effectively changing the inductance. As the coil can be in an oscillating circuit, this technique finds use in telemetry. Fig. 4 shows typical units.

Differential Transformer

Fig. 5 shows principle of use of an LVDT in an accelerometer and typical accelerometers using this technique.

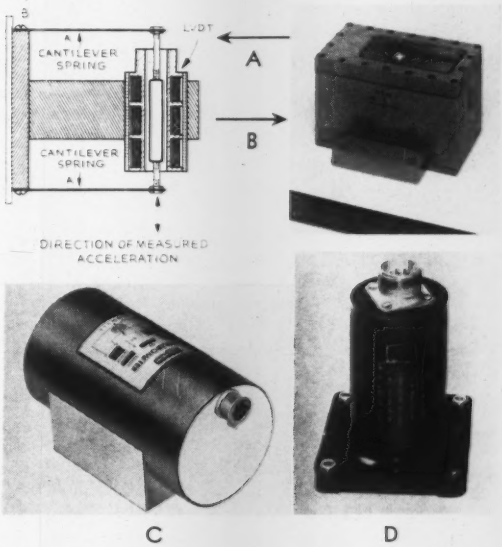


FIG. 5. LVDT ACCELEROMETERS. A shows principle. B shows Schaevitz unit; C shows Giannini unit with low threshold sensitivity (0.0001g); D shows Gulton Glennite unit with self-contained calibration system.

TABLE 2—CHARACTERISTICS OF FOUR STRAIN-GAGE ACCELEROMETERS

MODEL	±G	f_n cps	*Res. ohms	Max. V Volts	MV/V (Max. G)	MV/G (Max. Volts)	Microamps/G (40 ohm load) (Max. Volts)
MF-4-30-120	4	30	120	8	2.8	5.6	35
MF-10-50-500	10	50	500	24	4.6	11.0	20
MF-50-130-120	100	130	120	8	3.1	0.5	3
MF-100-185-120	50	185	120	8	3.1	0.25	1.5

*Other resistance values available.

Courtesy B&F Instruments, Inc.

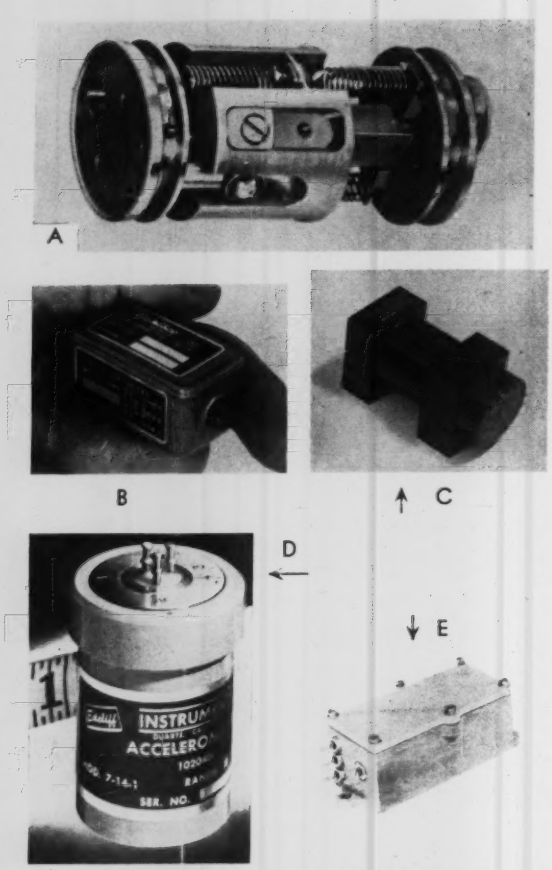


FIG. 6. POTENTIOMETER-TYPE ACCELEROMETERS. A, Giannini unit, showing mass-spring elements; B, Genisco unit weighs only 3 ounces, is available with 2-axis sensitivity; C, Gulton-Glennite AW-1 Series; D, Edcliff accelerometer; E, Fairchild Model TA-100.

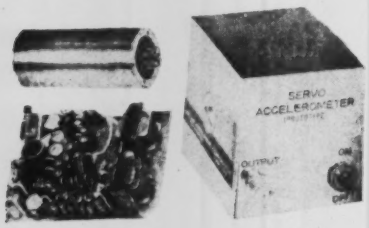


FIG. 7. SERVO ACCELEROMETER of Kistler.

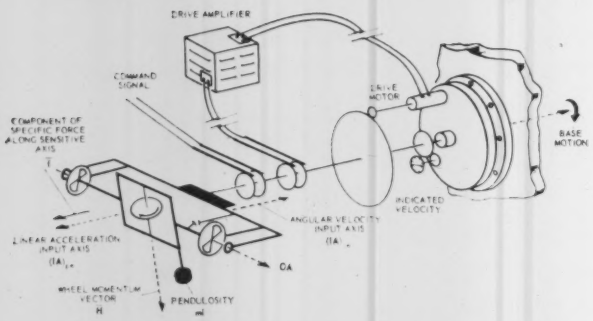


FIG. 8. ELEMENTS OF A GYROSCOPIC integrating accelerometer used for velocity measurement.

Potentiometer

Accelerometers are available in which the mass moves the wiper of a potentiometer (Fig. 6). The basic advantages are large possible motion of mass (above 0.5″), little accessory instrumentation, and large output. Disadvantage is relatively low natural frequency, limiting use to less than 100 cps.

Vibrating Wire

The vibrating wire uses the spring displacement to change the frequency of a vibrating wire. The advantage is easy conversion to digital readout (simple pulse count) and adaptability to digital techniques.

Variable Capacitance

This accelerometer uses the spring displacement to change the effective capacitance of a capacitor. Its advantages are simplicity of pickup and low-temperature sensitivity. (The capacitance pickup is discussed in the article "Displacement Measurement.")

Servo Accelerometer

Fig. 7 shows a "servo accelerometer" using a spring-suspended inert mass or sensing element with a forcing coil for magnetic constrainment on one end, and a pickoff coil for detection of displacement on the other end. Both coils are suspended in magnetic fields. The forcing coil is completely immersed in the constant field of a strong permanent magnet with circular air gap while the pickoff coil is subjected to the a-c field of an electromagnet.

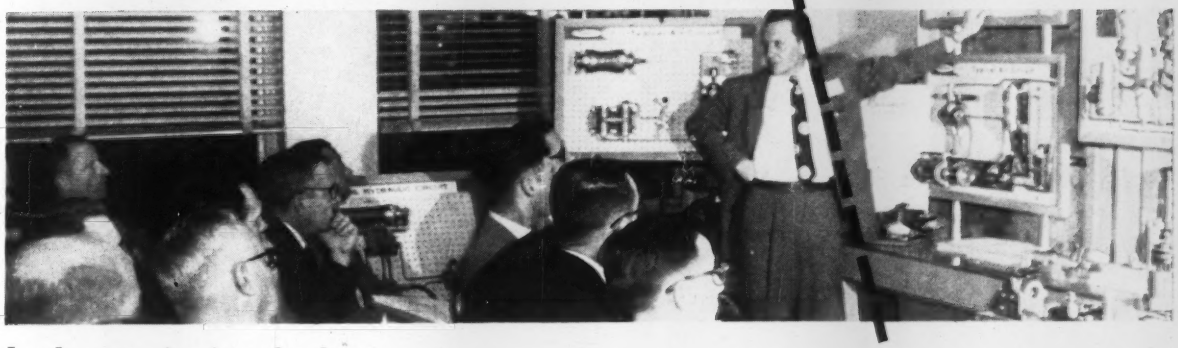
When an acceleration force is acting on the inner sensing element, it will tend to shift its position and a voltage will be generated in the pickoff coil. This voltage is amplified and demodulated in a miniature transistorized servo amplifier, the output of which feeds back into the forcing coil. The electromagnetic force generated in the coil exactly balances the acceleration force acting on the inert mass and keeps the sensing element centered.

Gyroscopic Precession

The rate of precession of a pendulous gyroscope depends on the force exerted by the pendulous mass. This pendulosity torque due to acceleration acting on the mass can be opposed by a spring to effect acceleration sensitivity. Gyro accelerometers (Fig. 8) are the heart of inertial navigational systems, with velocity being detected by integrating the output of the accelerometer.

Direct Recording

The direct-recording accelerometer uses a pen or stylus attached directly to the mass in order to produce a record of acceleration. This technique is used in seismographs as discussed elsewhere in this issue. (See article "Vibration Seismographs.")



In the morning, a school . . .

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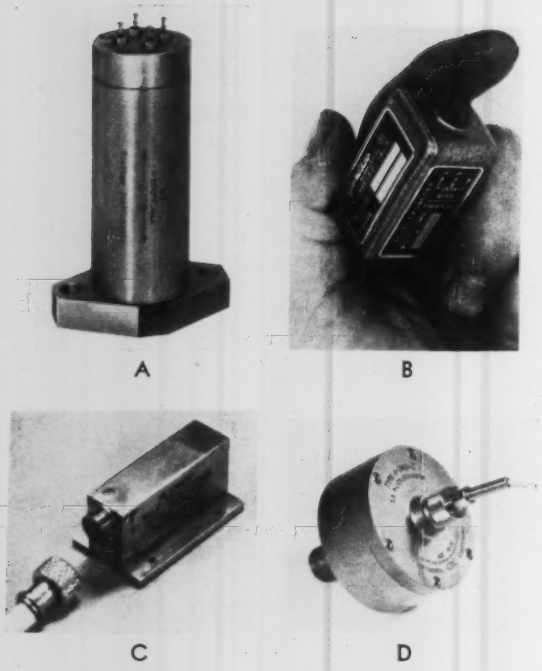
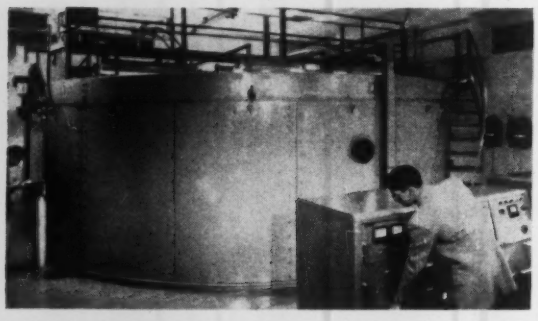
In the afternoon, a show.

Accelerometer

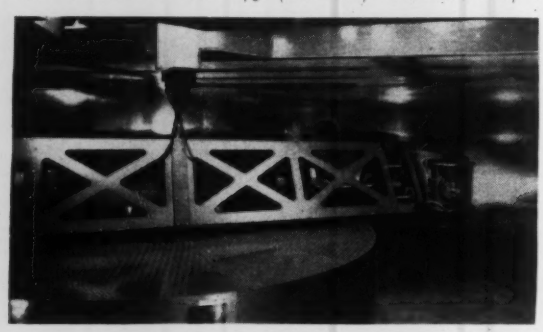
ALVIN B. KAUFMAN
Litton Industries



STATHAM strain-gage accelerometer (A), Genisco potentiometric accelerometer (B), Gulton barium-titanate accelerometer (C), and CEC electrokinetic accelerometer (D).



LARGE, PRECISION centrifuge designed originally to calibrate an accelerometer. In addition to the constant g developed by the rotating arm, the housing at the precision end can be spinning to add an oscillating g component. Accuracy of angular velocity is within 1 part in 400,000 and of radius of gyration within 1 part in 200,000. Over-all error in gravity field is less than 0.001%. (Courtesy Genisco, Inc.)



LINEAR ACCELEROMETERS can be divided into two groups—absolute and vibratory. An absolute accelerometer indicates both steady-state and vibratory g forces; examples of these are strain-gage and potentiometric accelerometers. Vibratory accelerometers indicate changing forces only, but do not respond to steady-state forces. Examples of these are barium titanate and electrokinetic accelerometers.

Absolute accelerometers can be calibrated by use of the earth's gravitational force (0 to $\pm 1g$), or by a centrifuge. The technique is simple in both cases, but when using a centrifuge a warning note is in order. The potentiometric accelerometer employs a mass (or weight) which may move a considerable distance under various g loads. It is therefore essential to either physically or mathematically correct for this motion when the accelerometer is calibrated on a centrifuge because the seismic mass movement may appreciably change the centrifuge-accelerometer radius.

Vibratory Accelerometers

The vibratory accelerometer presents a different calibration problem where high accuracy, high frequency, or low g forces are involved.

Since all commercial electro-dynamic shakers have a 50:1 or smaller ratio between rated output force (in pounds) and weight of moving components (in pounds), no more than 50 g is directly available on any shaker[1]. Shakers of large force output are selected not for a huge g-force output but for the capability to shake a larger mass at accelerations under 50 g. Smaller shakers have less stray magnetic field to interfere with calibrations; also, sidesway is less

Calibration

Description of seven methods for dynamic calibration of accelerometer displacement reveals state of the art.

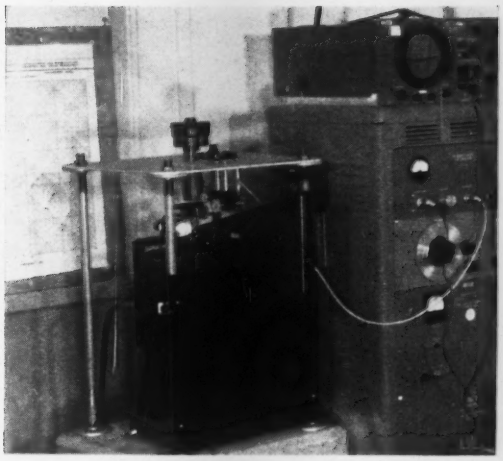


FIG. 1. PROJECTED-LIGHT displacement-measurement system.

serious in the smaller shakers[2] (the Calidyne A83 shaker with a force output of 100 pounds has been known to produce full-scale deflection of a nearby meter due to stray magnetic field flux). In addition to these reasons, a shaker is selected on the basis of other requirements.

Harmonic content in the driving power is undesirable. Also, low-frequency ripple noise and flutter are quite common and serious sources of error in commercial shakers. The g force of such low-frequency disturbances is exceedingly small, but the amplitude is large and serves to mask the amplitude measurement at the higher desired frequencies. Crystal shakers overcome some of these deficiencies but produce adequate g forces only at high frequencies and for small loads.

The three measurement items of chief concern in using a shaker are (1) true amplitude at the frequency for which g force is computed, (2) sidesway, and (3) frequency. The g force is a function of displacement and frequency. The equation $g = 0.0511Df^2$ (where D is double amplitude or DA in inches, f is frequency in cps, and g is peak value) indicates a requirement for accurate frequency measurement. Commercial digital frequency meters meet this calibration requirement.

Sidesway introduces a vector displacement not indicated by many displacement measurement systems. True displacement is undoubtedly the most complex measurement parameter, especially at high frequencies and at moderate g forces where displacement may be in microinches. Since all calibrations "boil down" to displacement measurement, displacement sensing accuracy is a good factor of merit.

Measurement of Displacement

The seven major methods used for the measurement of displacement or the dynamic calibration of accelerometers are as follows. (the specific techniques involved are discussed in the references noted):

1. Projected Light Source

This system employs a back-illuminated slit or hole (generally 0.001") mounted on the shaker work platform. A magnifier mounted on the shaker frame focuses a bright image of the slit on ground-glass-screen rule at suitable intervals. The transverse motion of the slit then appears as a broadening of the bright line against the ruled lines. Unfortunately, the magnifier magnifies the slit width as well as the amplitude of motion so that no better resolution than ±0.001" is obtainable (1% of typical 0.100" DA range), due in part to the granulation and halation inherent in the ground-glass screen. Such an error is equivalent to 2 g at 200 cps. Use in the frequency range of 10-100 cps is indicated. Sidesway cannot be monitored.

A typical commercial application (Fig. 1) is the Calidyne Optical System, Model 34.[2,13]

2. Microscope

The microscope can handle smaller displacement (0.010" DA for 1% accuracy) because its measurement accuracy is ±0.0001". Thus, it can be used at higher frequencies at the same g force. This measurement method has an added advantage in that sidesway also is monitored and can be measured. Usable range is about 0.100" to 0.001".

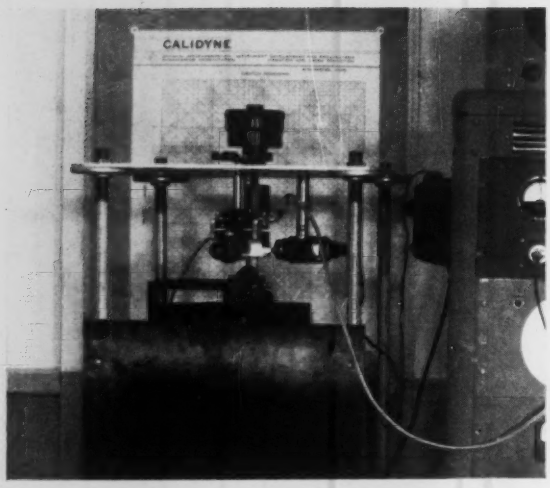


FIG. 2. MICROSCOPE DISPLACEMENT and sidesway monitor measurement system.

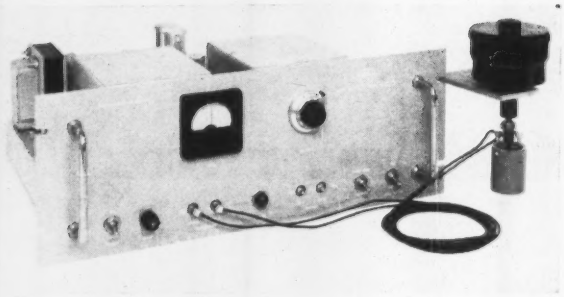


FIG. 3. A DEVELOPMENTAL non-contacting displacement calibrator with its measurement pickup. (Photo courtesy Arnoux Corp.)

Fig. 2 shows a typical microscope installation. A light source illuminates emery cloth; the reflection from a selected crystal is observed for displacement and table motion. Reference 2 specifies components.

3. *Shaker Velocity-Pickup Coil*

This system does not and cannot measure directly either displacement or acceleration because both are maximum when velocity is zero. This system is full of traps, pitfalls, and involvements, but has one advantage in that the effect of low-frequency noise is minimized. The velocity signal must be integrated to indicate displacement, and the resultant signal is accurate only with sinusoidal signals of low harmonic content. Sidesway is not measured so the signal does not indicate true displacement if sidesway is present. Specific parameters are presented in References 1, 2, 3, 4 and 13.

4. *Calibrated Accelerometers*

Three light-weight accelerometers mounted on the shake table can measure acceleration along three axes. However, they require several primary standards to calibrate them initially throughout the frequency range used. They can be calibrated initially with the microscope at low frequencies, or with a displacement calibrator at high frequencies (see next item, 5). Where barium titanate accelerometers are used, the output signal directly indicates vibratory g force independent of frequency. For this reason the system can be calibrated at low frequency via the microscopic technique, and used up to approximately 10-20% of the accelerometer f_n, regardless of critical damping (within 0.4 to 0.9), and without a high-frequency calibration.

This system, allowing direct readout of g force, is excellent for production calibration of accelerometers. Low-frequency table noise is not a measurement problem as with the optical system.[5]

5. *Displacement Calibrator*

The use of either a non-contacting mutual inductance, a capacitance pickup, or a light-beam follower allows direct measurement of table motion from static through a high-frequency dynamic range. Low-frequency table noise, 120-cps power-supply table motion (or ambient light fluctuations), and linearity present problems. Discounting these factors, accuracy can be as high as one microinch, but is usually 5 to 100 microinches. The mutual inductance and capacity units employ a precision micrometer for calibration of the pickup with static deflections; therefore, accuracy of the system for quasi-static through the full range of dynamic frequencies used must be evaluated.

Fig. 3 shows a developmental mutual-inductance displacement calibrator; Fig. 4 shows the pickup installed on a shaker. The unit shown does not rely on absolute linearity; an oscilloscope is used as a transfer indicator. The dynamic table motion pattern is matched to the previous scope amplitudes obtained by micrometer adjustment. Typical circuits and equipment can be reviewed by referral to References 1, 6, 7, 8 and 9.

6. *Interferometer*

The interferometer (Fig. 5) is useful in the range between 4 and 200 microinches and indicates displacement accurately at 4 microinch intervals, depending on light source. Accuracy is approximately 6%. In general the interferometer method of displacement calibration is considered applicable only for precise laboratory work. However, the advent of a commercial unit has made feasible production-type calibrating. The difficulties in technique involved, and the usable range, indicate it is most applicable in conjunction with crystal shakers. Electro-dynamic shaker-table noise cannot be tolerated. Sidesway is not permissible with the crystal or electro-dynamic shaker.

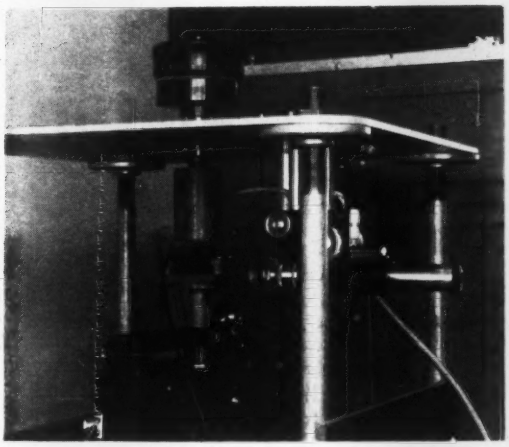


FIG. 4. NON-CONTACTING mutual-inductance displacement calibrator pickup with its micrometer head is shown at top. A Gulton A500 Series accelerometer and a microscope system are also visible.

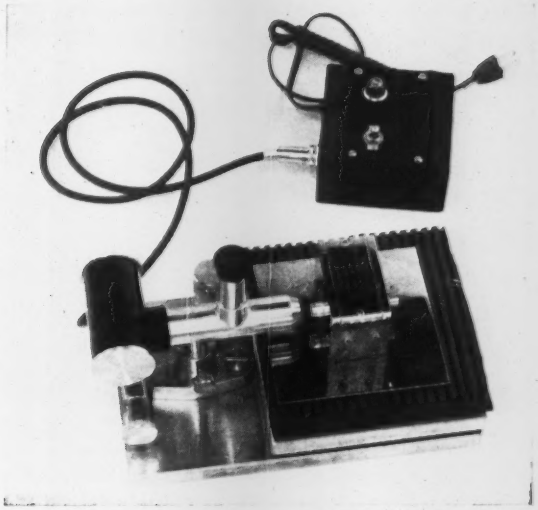


FIG. 5. GULTON AT-16 interferometer with AT-20A crystal shaker.

This method of displacement measurement is best suited for high-frequency, high-g calibrations[10,11,12].

7. Reciprocity

Displacement is not measured or required for this indirect method of calibration, which depends on (1) the existence of coupling between seismic mass and accelerometer case and (2) exact knowledge of the coupling. Thus, the method might be used on a compression-type crystal accelerometer but would fail completely when used on some accelerometers where the seismic mass is mounted at its motional node.

Strain-gage and potentiometric accelerometers cannot be calibrated by this method. The seismic mass must be capable of electrical excitation such that case movement occurs. Case coupling coefficients and other factors indicate that this method of calibration is not, in general, satisfactory[14].

Conclusion

The data presented indicate the major systems and parameters for accelerometer calibration. To a great extent the selection of the displacement or calibration measurement system depends on the limitations in calibration accuracy and the frequency spectrum required.

If the accelerometer is a first-order system with its damping known, its frequency response[15, 16] can be predicated on the f_n of the accelerometer, and low-frequency calibration measurements suffice. Unfortunately, most accelerometers are not first-order systems; nevertheless, flat frequency response to 10-20% of the f_n (where $h = 0.4$ to 0.9) can be assumed. Use of higher frequencies makes calibration necessary.

Resonant beams require one of the measurement systems discussed. Ballistic pendulum[17] and shock devices were not considered in this discussion of vibratory calibration methods.

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17. Alvin B. Kaufman, "Accelerometer Calibration by Ballistic Pendulum," *Instruments & Automation*, July, 1956.

Vibration

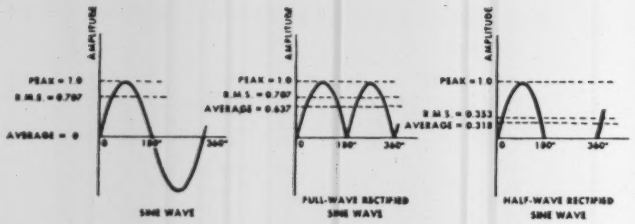


FIG. 1. SINUSOIDAL DISPLACEMENT relationships.

VIBRATION is a broad term that refers to "oscillation and resonance," but which actually involves three measurable variables—(1) displacement, (2) velocity, (3) acceleration. The frequency of the vibration, which can be and often is measured separately as a fourth variable, relates the three basic variables: knowledge of any two will give the frequency *if* the signal is sinusoidal.

A "vibration meter" indicates all three variables, having scales calibrated in displacement (inches), velocity (inches/sec), and acceleration (inches/sec/-sec). The scales usually are calibrated in rms values, although some engineers prefer double-amplitude (DA) or peak-to-peak calibration. Note: Instruments that measure only displacement or velocity or acceleration should be called by the variable they measure even though used to measure a "vibration."

Knowledge of *displacement* is important where the amplitude of the motion is critical, as in assemblies where parts must not touch—or where it indicates stresses to be analyzed.

Knowledge of *velocity* is important in acoustic and noise measurements. This is because the sound pressure in air produced by a vibrating surface is proportional to the velocity of the vibration (when the wavelength of the sound is shorter than the distance from the back to the front of the vibrating part).

Knowledge of *acceleration* is essential when forces, loads and stresses must be considered—that is, where the motion of a mass might cause failure. As $F = ma$, the force produced by a moving mass is a direct indication of acceleration, and vice versa. Acceleration measurements also are useful for noise measurements at low frequencies, where the wavelength is longer than the back-to-front distance of the vibrating part.

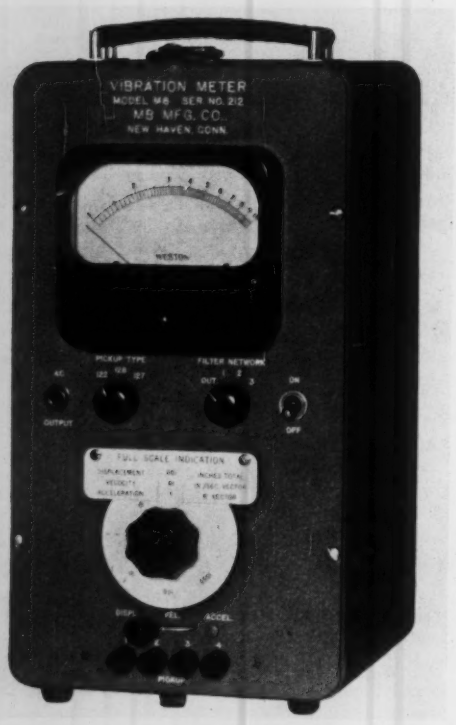
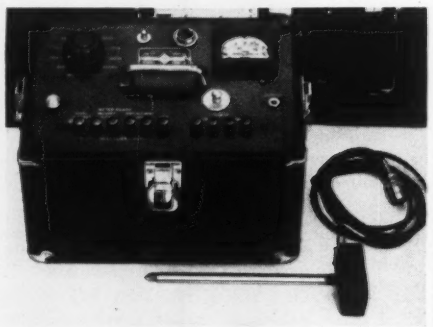


FIG. 2. VIBRATION METER Model Mb measures velocity, differentiates for acceleration, integrates for displacement. (Courtesy MB Mfg. Co.)



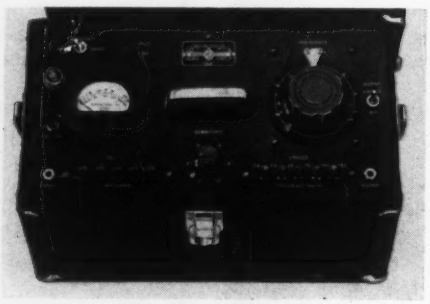


FIG. 3. VIBRATION METER Type 761-A (top) uses crystal accelerometer transducer. Velocity and displacement are found by integrating. Analyzer (below) reveals relative amplitudes of the component frequencies. (Courtesy General Radio Co.)

Meters Indicate X, $\dot{X}$ and $\ddot{X}$

In this situation the acceleration of the part can be a better indication of the vibration than the velocity because the air is pumped back and forth from one side of the vibrating element to the other without radiating much sound energy. Hence noise measurements associated with small machinery often are made by acceleration measurements.

A general-purpose vibration meter indicates all three variables from their relationships. If the displacement x is sinusoidal (Fig. 1):

$$x = A \sin (2\pi f)t \quad (1)$$

$$v = dx/dt = (2\pi f)\, A \cos (2\pi f)t \quad (2)$$

$$a = d^2x/dt^2 = -(2\pi f)^2 A \sin (2\pi f)t \quad (3)$$

where A is maximum displacement and f is frequency of motion.

Owing to these simple relationships between displacement, velocity and acceleration, a vibration meter could be made in the three following ways:

1. Measure displacement: differentiate once for velocity; differentiate once more for acceleration. As this technique would accentuate high-frequency noise signals excessively, it is not used.

2. Measure velocity: integrate the velocity to get displacement: differentiate the velocity to obtain acceleration. This technique is used in the instruments shown in Figs. 2, 4, and 5.

3. Measure acceleration: integrate once for velocity; integrate again for displacement. This technique is used in the instrument shown in Fig. 3.

Equation 1 says that the maximum peak-to-peak displacement (double-amplitude) is 2A; that rms displacement is $A/\sqrt{2} = 0.707A$; average (full-wave rectified) displacement $= 2A/\pi = 0.637A$; average double amplitude displacement $= 4A/\pi = 1.273A$.

Equation 2 shows that velocity is proportional to frequency and amplitude.

Equation 3 shows that acceleration is proportional to amplitude and the *square* of frequency. This means that the higher-frequency components in vibration become progressively more important in velocity and acceleration. This becomes significant when dealing with nonsinusoidal signals, which can be represented as a Fourier series of increasing frequency.

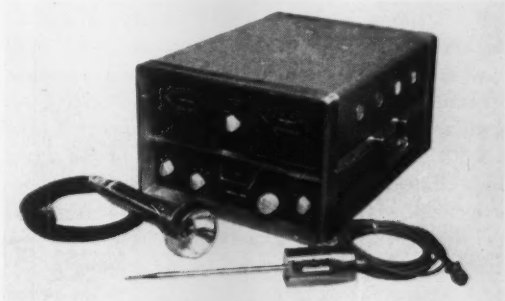
Frequency

For sinusoidal vibrations the frequency of vibration can be calculated from a reading of displacement and velocity ($f = v/2\pi x$). But where the vibration is not sinusoidal, the vibration meter cannot give the frequency, although the readings will be in rms values of the waveform. In this event it is necessary to use a frequency analyzer (sometimes called a vibration analyzer, sound analyzer, wave analyzer, or octave analyzer). This instrument separates the frequency components or bands of any signal within its range and indicates their magnitudes. A typical analyzer is shown in Fig. 3.

The IRD Model 600 Vibration Analyzer shown in Fig. 5 measures frequency directly on one indicator, and indicates amplitude or velocity on another indicator. It uses a velocity-sensitive pickup.

FIG. 4. VIBRATION METER Model T-1A provides selector switch in upper right of panel to permit reading displacement, velocity or acceleration when used with velocity-sensitive pickup. (Courtesy Southwestern Industrial Electronics Co.)

FIG. 5. VIBRATION ANALYZER IRD Model 600 measures amplitude, velocity and frequency directly. (Courtesy International Research & Development)



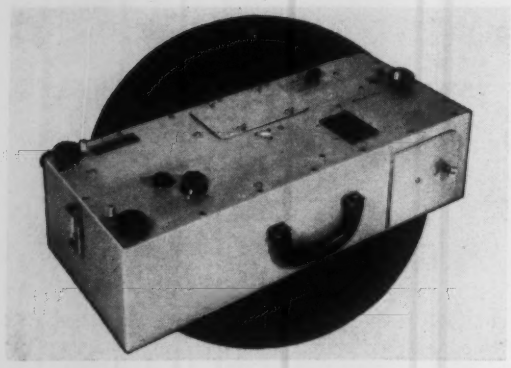


FIG. 1. PORTABLE BLAST and vibration seismograph uses three pendulous masses for three-dimensional recording. (Courtesy Sprengnether Instrument Co.)

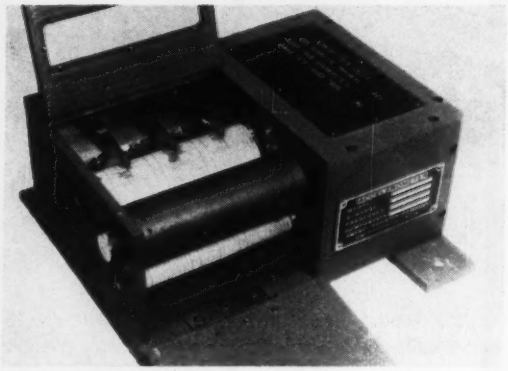


FIG. 2. MODEL RM three-way accelerometer uses wax-coated chart. (Courtesy Impact Register Co.)

VIBRATION SEISMOGRAPHS AND

The seismic vibration analyzer, or seismograph, has the recording pen or stylus attached directly to the seismic mass, and is displacement sensitive.

THE TECHNIQUE of having the seismic mass move a recording pen or stylus directly is used in seismometers and in some vibration analyzers. The seismic vibration analyzer and seismic accelerometer use the same principle, but the accelerometer is a short-period (high f_n) instrument with aperiodic damping, responsive to acceleration; the vibrometer usually has a long natural period (low f_n) and little damping, so that it measures displacement.

Fig. 1 shows the Sprengnether portable blast and vibration seismograph. The basic seismometer system consists of two inverted pendulums which respond to perpendicular components of the horizontal ground motion, and a vertical-motion spring-supported pendulum for recording the vertical motion of the ground. Eddy-current damping is done via a vane in a magnetic field. Motion of the seismic masses is recorded photographically with a mechanical optical lever system that magnifies the motion of the ground by a factor between 50 and 500.

Fig. 2 shows the Model RM three-way accelerometer of the Impact Register Company, which records accelerations directly in three axes. It features pneumatic damping (a pneumatic piston with fixed orifice is used to obtain 0.7 critical damping). The accelerometer springs can be interchanged for different ranges.

Fig. 3 shows the Cambridge Instrument double (2-plane) accelerometer. The two masses are connected to styluses which mark on celluloid film. Both movements are critically damped electromagnetically. A third stylus marks time or datum lines. Optical magnification of the record permits reading to 0.004".

Fig. 4 shows the Askania Vibrograph, a direct-recording spring-mass instrument. Damping is by a rubber bellows. The inert mass is suspended on leaf springs. Timing channel records time marks. Accelerations and displacements can be measured by conventional technique using the resonance curves for a mass-spring system. Damping is independent of temperature.

Fig. 5 shows a "Vibraswitch" that is used as a malfunction detector. It employs a magnetic circuit op-

FIG. 3. TWO-PLANE ACCELEROMETER scribes on celluloid film. (Courtesy Cambridge Instrument Co., Ltd.)

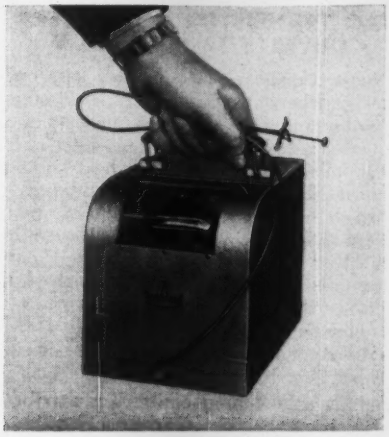


FIG. 4. ASKANIA VIBROGRAPH has time marker. Recording is made by sapphire stylus on waxed paper tape. (Courtesy EPIC, Inc.)

VIBRASWITCHES

posed by inertial and adjustable spring forces in the actuating mechanism. The armature is constrained to only one type of movement by a frictionless flexure pivot composed of two overlapping blocks and a leaf spring loaded in one direction to hold the block together. The armature rocks on the pivot being forced in one direction by the adjusting spring and the other direction by the magnet.

When the entire assembly is subjected to vibration perpendicular to the base, the peak acceleration times the effective mass of the armature produces an inertial force aided by the spring, tending to pull the armature away from the stop pin and open the air gap. When the peak acceleration exceeds a pre-selected level, the armature leaves the stop pin, increasing the gap with the armature continuing to move up until it strikes the latch magnet, actuating the switch during the upward travel. It may be reset by depressing the reset button or applying power to the electrical reset coil.

Inertia switches of three basic types (with axial, radial and omnidirectional sensitivity) are available from Inertia Switch, Inc. A precision-ground steel ball is held against a solid base by a uniform magnetic field. When the opposing force of acceleration exceeds the magnetic force, the ball immediately moves—to make or break an electrical contact. The switch can be used for direct circuit closure, or to actuate relays or thyratrons at a given acceleration.

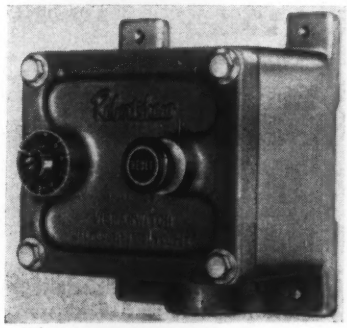
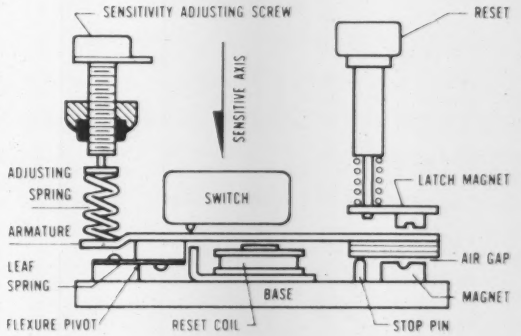


FIG. 5. VIBRASWITCH IS malfunction detector. (Courtesy Robertshaw-Fulton Controls.)



ELECTRONIC

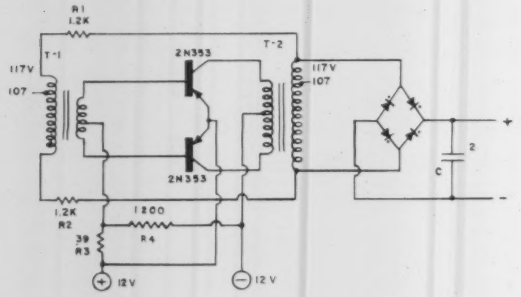
The circuit is the heart of all electronics. Here are 3 more basic and interesting circuits. Unless marked, resistors are in ohms, capacitors in microfarads.

D-C TRANSISTOR CONVERTER CONVERTS 12 V TO 300 V

This low-cost transistorized converter uses only standard inexpensive filament transformers. One major warning must be observed: The heat sink must be of adequate size. Inadequate heat sinks cause the majority of transistor failures in supplies of this type. The heat sinks required for the circuit illustrated are ¼" aluminum by 1½" square for each transistor. The transistors are insulated from the heat sinks by a thin piece of sheet mica which prevents shorting of the collectors when the two heat sinks are mounted on the chassis. If desired the mica washers can be eliminated and the heat sinks mounted above the chassis (and separate) with standoffs. If aluminum is not available, brass or copper is suitable. It is also possible to use sheet aluminum.

The circuit is a "common emitter" multivibrator; the feedback is accomplished by connecting out-of-phase windings back to the base of the transistors. The two transistors operate as switches, one being on while the other is off.

When 12-v d-c power is initially connected, one transistor will begin conducting slightly before the other, owing to slight differences in transistor characteristics. Collector current of this transistor, as it increases in the primary winding of transformer T-2, induces voltages in the other windings of T-2. Voltage at the secondary of T-2 is fed back to the bases of the transistors via transformer T-1. Polarity at the bases is chosen to reinforce the conduction in the already conducting transistor, and to hold the other transistor cutoff.



Induced voltages in the windings of T-2 are proportional to the *rate of change of flux* in the winding driven by the conducting transistor, and hence are maintained as long as increasing collector current produces increasing flux. When the flux in the core reaches saturation level, the rate of change of flux falls to zero. There is a corresponding drop in induced voltages. With the base current of the conducting transistor thus decreasing, collector current begins to decrease. This produces induced voltages of opposite polarity, cutting off current in the initially conducting transistor, and causing the other transistor to conduct. The cycle then repeats continually, producing a square-wave output at the secondary of T-2. Output is rectified by the silicone bridge rectifier to provide 300 v d-c at the output terminals.

The required load dictates the feedback required. If an increased load is demanded the feedback may have to be increased by decreasing the resistance of R1 and R2 (keeping R1=R2). Resistors R3 and R4 form the biasing network for the transistors, providing enough starting bias to insure that the circuit will go into oscillation when power is applied. The circuit shown will oscillate between 200 and 500 cps (commercial and military converters generally oscillate between 800 and 3500 cps). The output voltage, determined by the supply voltage and transformer turns-ratio, remains fairly constant over a reasonable range of load current (output voltage drops 15% for 100% increase in load).

The circuits shown also will operate on 6 volts, producing about half the output voltage shown. Some care must be used not to make the value of the feedback resistors R1 and R2 too low; excessive feedback can destroy the transistors. If circuit does not oscillate, reverse leads to R1 and R2.

The rectifiers should be rated for the RMS value of the a-c output but at half the output current required. Sarkes Tarzian silicon rectifiers type 40K or M500 are ample. They are small and priced reasonably at $1.50 each. The dot on the circuit indicates the positive (red) side of the rectifier.

Philco transistors type 2N353 (PNP) at $3.75 each were used. CBS 2N256 or Bendix 2N235 or equivalent also could be used. All resistors are 1 watt.

A 1 or 2 uf capacitor provides sufficient filtering for most purposes. If additional filtering is required the addition of a small choke and capacitor (output) is advisable rather than increasing the input filter capacitor size. The capacitors can be either electrolytic or paper (oil-filled cans); for long trouble-free life, paper capacitors should be used.

Using the values shown on the schematic and a Stancor P6134 filament transform (117 v to 6.3 v at 1.2a) gave the following operating conditions:

Input Supply	Output	Oscillation Freq.	Efficiency
12 v at 4.0 amps	265 v at 110 ma	200 cps	67%
12 v at 2.5 amps	310 v at 60 ma	200 cps	60%

For lower-power operation the following values were used: R1 = 22K; R2 = 22K; R3 = 18; R4 = 1200; T1, T2 = Stancor P-8130, (117 v to 12.6 v C. T. at 2 amp.). This gave low-power operation as follows:

Input	Output	Oscillation Freq.	Efficiency
12 v at 0.75 a	175 v at 36 ma	295 cps	70%
12 v at 1.19 a	160 v at 65 ma	400 cps	72%

Source: Edwin Kaufman, Woodland Hills, Calif.; also Lansdale Tube Co., Application Note # 317.

CIRCUITRY

CHARLES F. KEZER

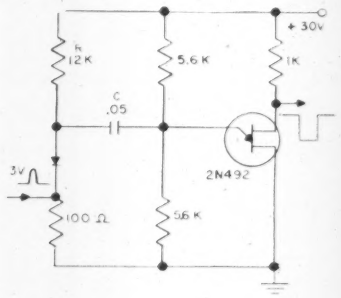
and

MILTON H. ARONSON

UNIJUNCTION ONE-SHOT MULTIVIBRATOR

Negative-going output pulses of predetermined duration are produced by this one-shot multivibrator, using a single unijunction transistor type 2N492.

In the quiescent state, the emitter is biased to 15 v by the voltage divider made up of the two 5.6K resistors. At this potential the emitter is non-conducting: it will conduct when its potential is raised to 62% of base 2 voltage, or 17 v. Quiescent base-to-base current is 2.6 ma, producing a 2.6 v drop in the 1K resistor; thus potential of base 2 is 27.4 v.



The transistor is triggered by applying a 1-usec 3-v trigger pulse across the 100-ohm resistor. This pulse, passing through the diode and capacitor C, appears at the emitter, raising its potential from 15 to 18v, which is above the 17-v level at which emitter conduction commences. Emitter current flow increases rapidly because of the negative-resistance characteristic of the unijunction transistor, dropping the emitter potential to 5 v.

The left-hand side of capacitor C was initially at 1 v dc (the forward drop across the conducting diode). The 10-v drop in emitter potential produces a corresponding drop at the left hand side of the capacitor, to —9 v. With —9 v at its anode, the diode is now reverse-biased, and is non-conducting. Capacitor C now begins to charge, via resistor R and the emitter to base-1 path, with the left-hand side of C rising in potential toward the supply voltage. The emitter is maintained in conduction by the capacitor charging current. Capacitor C continues to charge until the potential at the left hand side of C reaches ground potential (200 usec), and diode begins to conduct. The potential at the left-hand side of C quickly stabilizes at about 1 v, the forward drop of the diode.

With capacitor charging current no longer flowing in the emitter to base-1 path, emitter conduction can no longer be maintained, and emitter current quickly falls to zero. After a recovery period the circuit can be triggered again. If 350 usec is allowed for recovery, output pulse duration is affected by less than 5%; longer recovery time would permit less effect on duration.

Pulse duration can be changed by selecting different values of R and C. These should be temperature-insensitive components for best stability. Transistor characteristics depend on temperature, producing increase in pulse duration of 0.2% per C°.

Power supply: 30 v d-c at 8 ma, quiescent.

Input: Positive trigger pulses, 3-v amplitude, 1-usec width.

Output: Negative-going pulses of 4-v amplitude (amplitude increases 0.1% per C°); pulse duration of 200 usec can be changed by altering R and C.

Maximum duty cycle: 45% to maintain duration constant within 5%.

Rise time: 6 usec (negative-going).

Fall time: 2 usec.

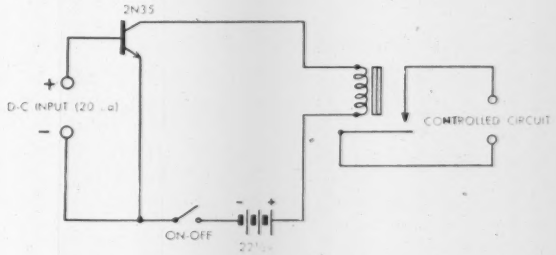
Pulse duration stability: Duration increases 0.2% per C°, and 0.8% per volt change in supply voltage.

Source: Semiconductor Products Dept., General Electric, Syracuse, N. Y.

TRANSISTOR AMPLIFIER OPERATES RELAY ON 20-MICROAMPERE CURRENT

A type 2N35 NPN transistor provides a current gain of 50 in this circuit, operating a 1-ma relay from input currents as low as 20 ua.

The relay shown (Sigma 4F 8000-ohm) is supplied normally for 2-ma closure current; it is easily adjusted for 1-ma closure by rotating its spring-tension screw



counter-clockwise for more sensitive response. If the relay is not readjusted, base current of 60 ua is required for closure.

Power supply: 22½-v dc at 1-ma energized; battery current is 5 ua (approx.) at zero input current.

Output: Contact closure.

Source: Booklet, 23 *Uses for Junction Transistors*, Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y.

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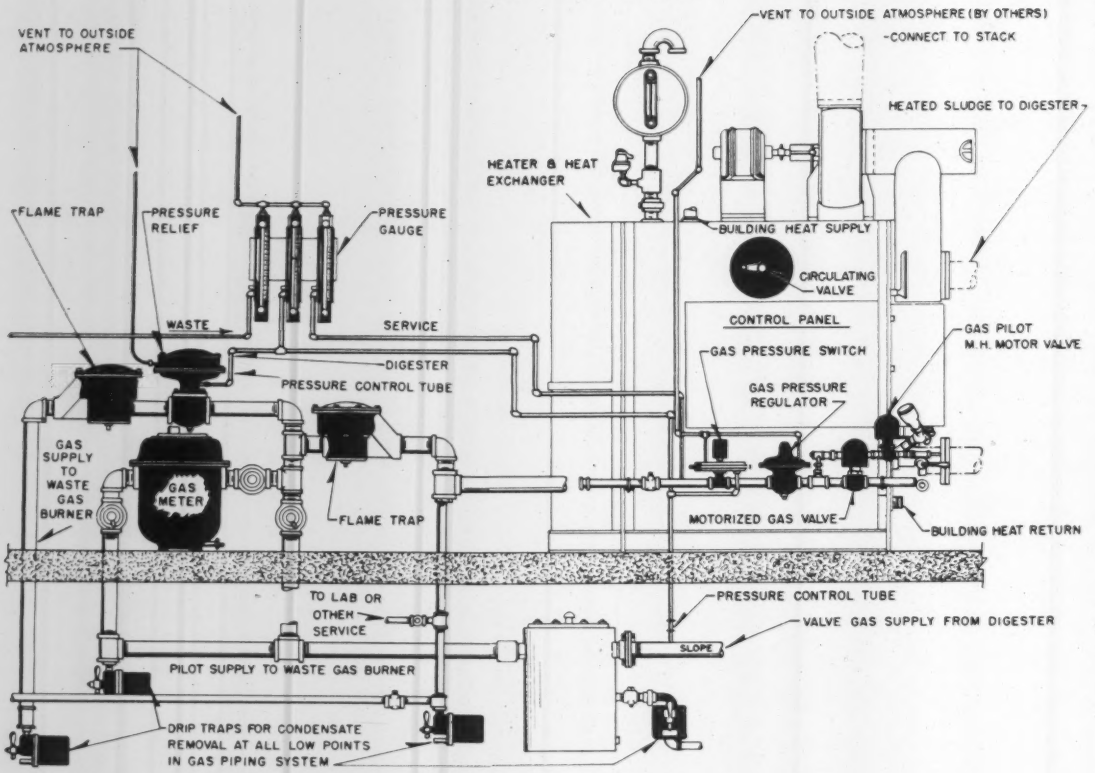


The use of sewage gas in disposal plants for generating heat and power has resulted in savings for many municipalities.

Sewage gas usually contains 65 to 80% methane, occasionally a small amount of hydrogen, and the remainder is carbon dioxide and nitrogen plus some hydrogen sulfide, with an average heat value of 650 BTU/cu ft (an average production of from 1/3 cu ft to 4 cu ft per day per capita shows the possibilities). The gas is best used by dual fuel engines which automatically switch over to a commercial supply when the sewage-gas supply runs low.

The gas output is metered as a check on the sludge digesters, and to evaluate the efficiency of the process. The meters shown are of the bellows type (dry-type) with an accuracy of $\pm 1\%$. The metering mechanism is easily exchangeable for servicing. As they require frequent drainage of condensate, manually-operated drip traps are provided as shown at the low points of the piping system.

A pressure relief valve and two flame traps guard the lines to the waste gas burner and to the heater. The heater furnishes heat to the building and includes a heat exchanger for pre-heating the sludge piped to the digester. On the heater there is a diaphragm-type self-actuated gas pressure regulator (Rockwell Type 120), a pressure switch which shuts off the supply at excess pressures and two motorized valves, one for the gas supply and the other one for the gas pilot.

Three manometer-type pressure gages indicate the pressure of (1) the gas supply, (2) the waste, and (3) the regulated service line. (Waste gas is excess gas that is burned off in the waste gas burner.)

Equipment used: Rockwell Sewage Meter; Rockwell Nordstorm Valves (usually lubricated plug valve, 4″, flanged end); Rockwell Pressure Regulator (Type 120 is common).

Source: Rockwell Manufacturing Company, Pittsburgh, Pa., Bulletin C-5200-3.

BLENDING OF PULP STOCK

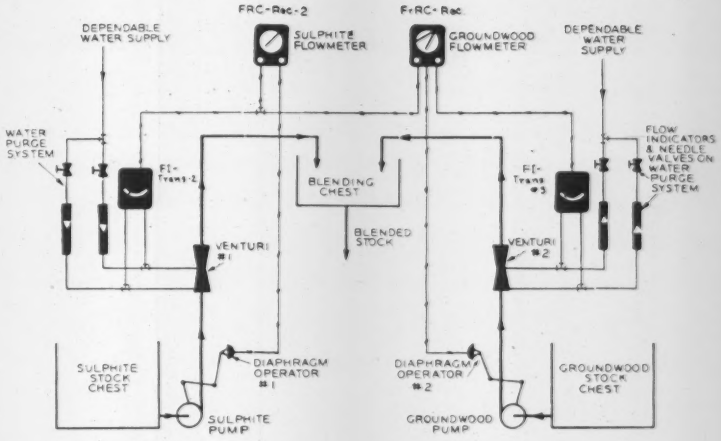
Stock from the sulphite chest (lower left) and stock from the groundwood chest (lower right) are brought into the blending chest (center) according to a predetermined ratio. The flow ratio control system offers the convenience of single-knob adjustment of total flow, while the ratio of fluids is maintained.

The sulphite flow set point is established manually at the sulphite flowmeter-recorder-controller, whose signal controls a diaphragm operator (#1) to vary a hydraulic coupling between the sulphite pump and its motor. This sets up the desired sulphite flow.

The flow of groundwood stock is ratioed to the sulphite flow. The sulphite flow signal is brought to the flow ratio recorder controller (FrRC). Adjustment of the ratio device permits the groundwood flow set point to be from 0.5 to 1.75 of the sulphite flow signal. Actual groundwood flow signal is compared to this ratioed set point and the resultant control signal is sent to the diaphragm operator #2, which varies the speed of the groundwood pump by varying the hydraulic coupling to its motor. Thus sulphite flow seeks its set point value and groundwood flow seeks a set ratio of actual sulphite flow.

Prior to this installation stock blending was accomplished by using two or more positive-displacement stock meters operated by variable-speed drives; blending had to be done manually.

Using a Venturi tube as primary element increases flow measuring accuracy, reduces space requirements, and lowers maintenance costs. However, there is the risk of the Venturi impulse lines being clogged by the stock. In this installation the differential pressure across the Venturi is carried to an indicating flow transmitter by ½" pipes. A reliable source of clear purging water, at pressures well above the pressure in the stock line, is connected to the impulse pipes to keep the impulse pipes from plugging. Hand-operated needle valves and rotameter-type flow indicators regulate the flow of the purge with differential regulators insuring that no error be introduced in the purge system regardless of variations in upstream or downstream pressure.



Equipment Used: FI-Transmitters 2 and 3 are Model BF 13A-1. FRC-Rec.-2 is Model 1A500 CW2 with proportional and reset. FrRC-Rec is Model 2A1X500 CR2 with proportional and reset; Venturis have throats of Type 304 stainless steel; purge system is conventional, with differential-pressure regulators (not shown).

Source: The Bristol Co., Waterbury, Conn.; also application Data No. 073.8.2-2.

LEVEL CONTROL VIA PUMP SPEED REGULATION AND BUBBLER

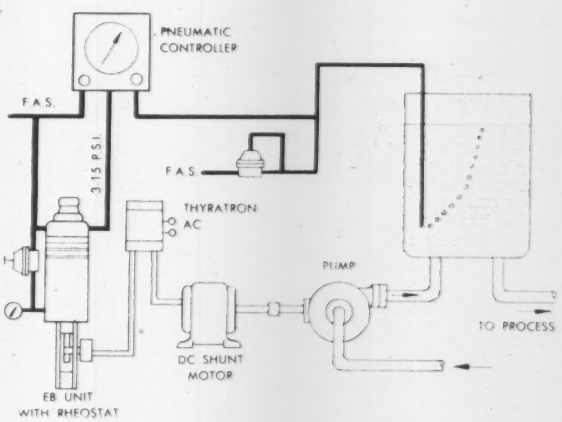
Where a pump feeds into a tank, level can be controlled either by a valve in the flow line or by changing the speed of the pump. The latter technique eliminates a valve, reduces motor power input, and provides for wide flow rangeability.

A simple way to achieve pump control is shown, using a pneumatic bubbler level detector to control an electric motor.

Level is sensed by a conventional bubbler dip tube connected to a controller. The controller develops a 3-to-15-psig signal proportional to level. This signal controls a pneumatic positioning unit, which in turn positions a small rheostat in the grid circuit of a thyratron-controlled speed changer. Other speed changers can be used as well. The speed changer controls the rpm of a d-c shunt motor, which changes pump speed to keep the level constant.

The controller (such as the U. S. Gauge Model 725 Pressure Pilot) has proportional control, but reset and rate are available when required by the process.

Source: Conoflow Corp., Philadelphia, Pa.



Journal of the S C M A . . .

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Industrial Telemetering

Most industrial telemetering signals are electric signals of various types.

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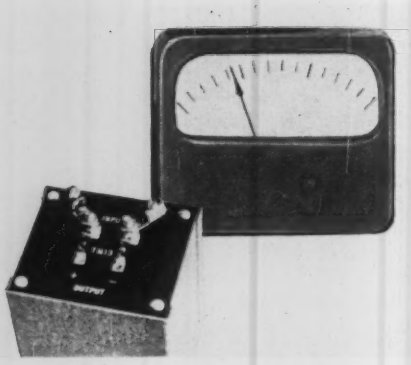

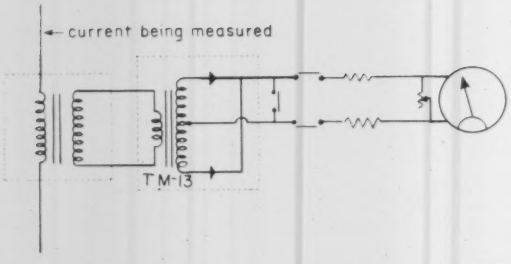

FIG. 1. D-C SYSTEM for alternating current uses isolating transformer. A-c voltage can be telemetered by similar system, but using voltage winding on primary.

May Meeting: Thursday 21st, Rio Hondo Country Club, Downey, California

Technical Program: To be announced.

TELEMETERING is becoming increasingly important in electric utility systems, gas distribution systems, pipe lines and waterworks.

The traditional method of presenting telemetered information (pressure, flow rate, specific gravity, etc.) has been by indicating instrument or circular-chart or strip-chart recorder. Modern usage also includes printed readings on adding-machine-type tape, log sheets and punch cards, or tapes to feed into modern data handling equipment. The telemetering channel may be pneumatic, hydraulic or electrical, the last being least expensive and most satisfactory where appreciable distances are involved.

The electrical channel can take the form of a wire circuit, a carrier current channel, or a microwave or UHF radio channel.

Electrical Signal Types

The most common signals used in electric-signal-type industrial telemetering systems are

(1) A direct current whose amplitude is varied,
(2) a pulse signal whose duration is varied,
(3) a sub-audio a-c signal whose frequency is varied, or
(4) a pulse signal where the number of pulses transmitted, or the position of certain pulses in a group, determines the reading.

Variable Direct Current

The first type (variable direct current) is used usually for voltage, current and position. It requires a wire circuit, and provides good accuracy, high response, and simplicity.

Presented at Instrument Short Course, SCMA, LAHJC, Jan. 1957.

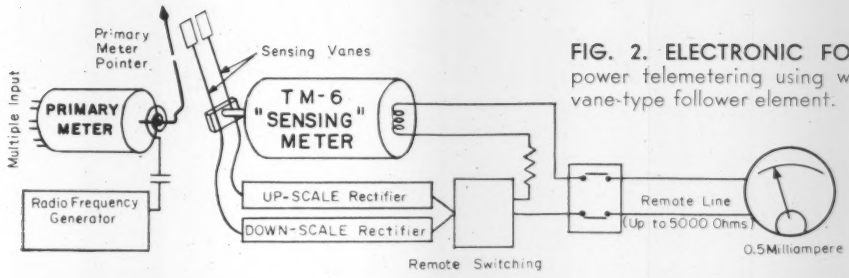

FIG. 2. ELECTRONIC FOLLOWER system for power telemetering using wattmeter element and vane-type follower element.

For telemetering an a-c *voltage*, a common method is to use a transformer whose rectified output passes over the wire circuit to a d-c milliammeter or voltmeter at the receiving location (Fig. 1).

For telemetering *alternating current*, a similar set-up is used, frequently involving only an isolating transformer and a rectifier with a d-c meter as receiver (Fig. 1). It is feasible to use an isolating transformer for each telemetered current value rather than going to complex switching arrangements.

These systems have the advantage that the scale on the receiving instrument is linear. Variation in line resistance can affect accuracy, although the impedance of the transmitting equipment is usually sufficiently high that normal variations in line resistance do not have serious effects. Leakage resistance also can affect accuracy.

A direct-current type of telemetering also can be used for telemetering *position*, using a voltage-divider rheostat (potentiometer). A regulated d-c supply is fed to the two ends of the rheostat: the arm takes off a voltage proportional to the position of the driving mechanism. A voltmeter at the receiving location comprises the receiving equipment.

Complex Variables

The d-c system is adequate for voltage, current and position. However, more complex variables, such as power, require a different type of telemetering instrument.

One common type is an electronic follower system (Fig. 2). This primary measuring instrument for killowatts is a conventional wattmeter (electrodynamometer). An r-f signal is fed to the pointer of the primary instrument by a signal generator. The pointer passes in front of two vanes attached to a milliameter movement. If movement of the pointer unbalances the r-f signal distribution between the two vanes, the electronic follower equipment repositions the milliammeter so that the vanes are "in coincidence" (or in line) with the pointer of the primary instrument. The same current through the milliammeter is sent through the wire circuit and operates another milliammeter at the receiving location. The receiver milliammeter is calibrated directly in terms of the value being measured.

This system has rapid response. It also compensates automatically for variations in line resistance because the current going through the tandem milliammeter is the same current going out over the line and into the receiving meter.

Most have a scanning mechanism at the transmitting point, which delivers a pulse signal whose duration is proportional to the variable as measured by a primary measuring instrument. At the receiving location the time duration of the signal is converted into a reading.

One common system uses a rotating cam arrangement as the scanning mechanism, and a similar motorized cam as a receiver.

Another time-duration system uses photoelectric technique (Fig. 3). At the receiving location the duration of the signal is converted into a direct current proportional to the value being telemetered. This system avoids problems associated with rotating contacts.

The time-duration telemetering system has the disadvantage that the scanning rate of the transmitter must remain constant, otherwise accuracy suffers. This means that the transmitter motor generally is of the synchronous type. Thus variations in power-supply frequency cause the scanning rate to vary and affect accuracy. This situation is further aggravated in those systems which use a motorized balancing type of receiver because both the transmitter and receiver motors require the same power-supply frequency.

Another disadvantage of most time-duration systems is slow response: several seconds may be required for a change to show up on the receiving equipment.

Time-Duration Systems

Time-duration systems can use either d-c signals or a-c signals.

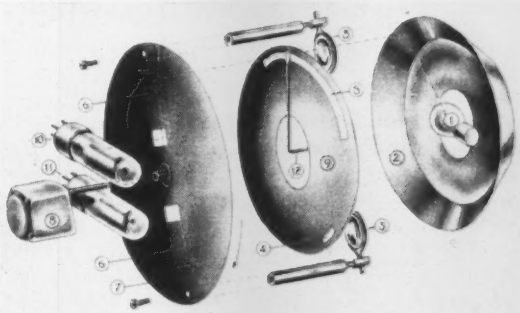

FIG. 3. PHOTOELECTRIC time-duration telemetering system. Plate 7 rotates at constant speed. Output signal (pulse) starts when aperture 4 passes light. Light from 5 continues until pointer is passed, cutting off signal. Signal cannot begin again until aperture 4 is illuminated.

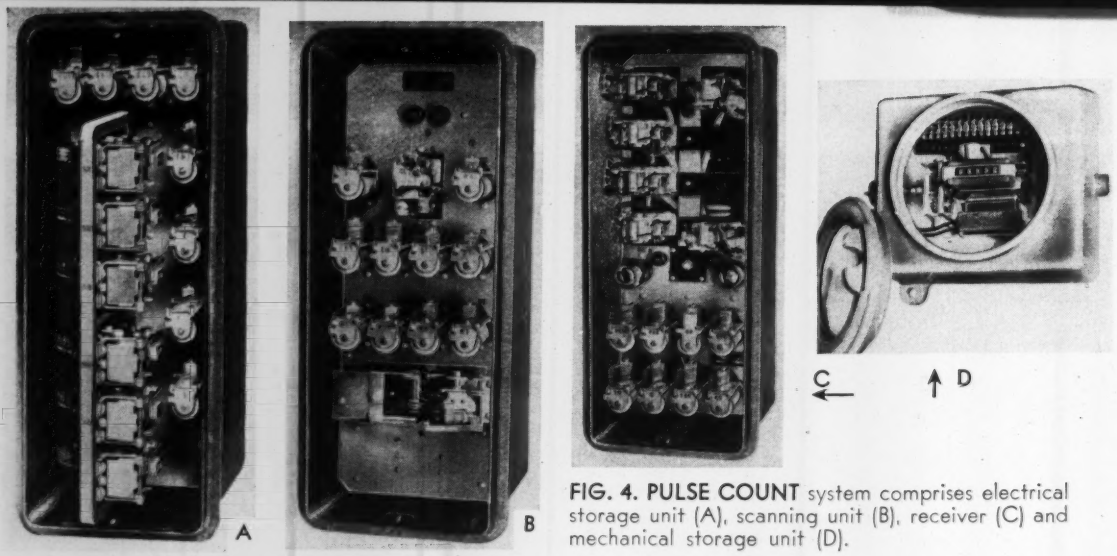

FIG. 4. PULSE COUNT system comprises electrical storage unit (A), scanning unit (B), receiver (C) and mechanical storage unit (D).

Time-Ratio Telemetering

This difficulty is overcome by using time-ratio telemetering. If the receiving unit of a time-duration system responds to the *ratio* of time-on to time-on plus time-off, then accuracy is not a factor of scanning rate. Time ratio telemetering also has more rapid response.

Totalizing

Sometimes it is desirable to totalize telemetered readings, particularly kilowatts. This often is done by retransmitting slidewires on recorders. The electronic follower system, the photoelectric duration-of-time method, and the time-ratio method described all have the ability to provide this totalizing without use of retransmitting slidewires.

Pulse Counting

Pulse count systems have been used in various forms for several years in the electrical utility industry to telemeter kilowatt-hours, and also for telemetering total flow in gas and fluid measuring system. The measuring instrument closes a contact for each unit value of the product that is measured (each kilowatthour, each barrel, etc.) and transmit a pulse for each unit value. At the receiving location a simple magnetic-operated counter counts the pulses coming in; this appears on a cyclometer-type indicator.

This system has certain inherent disadvantages. One is the fact that if a channel outage occurs it is necessary to send someone to the measuring or transmitting location to read the meter and telephone in the reading at that particular time. An operator at the receiving location then can synchronize his cyclometer counter with the correct reading. This type of telemetering also has the disadvantage that is requires full-time use of the channel. It is also plagued with the ever-present possibility that pulses may be picked up or lost to give incorrect readings.

A pulsing-type system which overcomes these disadvantages uses a contact-making device, but each time the meter contact closes, a storage unit (stepping switch) at the transmitting point advances one position (Fig. 4). When this unit stepping switch advances ten positions, it advances a tens' stepping switch one position. Each time the tens' stepping switch advances ten positions, it advances the hundreds' stepping switch one position and so on. This unit serves only to store the contact closures of the measuring instrument in a digital form.

When a reading is required, a transmitting unit connects into the storage unit and first scans the unit stepping switch, transmitting a pulse for each contact it scans until it reaches the contact corresponding to the units' reading. At this time it transmits a long pulse, then continues transmitting short pulses for a total count of ten. The same procedure is followed for the tens' stepping switch, the hundreds' stepping switch, etc.

At the receiving location the units' impulse counter counts the pulses for the units part of the reading until the long pulse comes in, then stops counting. The tens' pulses are counted in a similar manner, etc. A separate impulse counter counts both long and short pulses and will detect any errors of transmission due to extra pulses picked up or pulses lost. If such a situation does occur, the entire reading is rejected.

As transmission occurs only on demand, the channel is not tied up except for the few seconds required to transmit a reading. If a channel is lost, a correct up-to-date reading can be obtained when the channel is restored. If extra pulses are picked up, or if pulses are lost during transmission of a reading, this is detected and the receiving operator informed of this fact. The first complete transmission received is correct.

This also has the advantage that several storage units can be used with one transmitting unit and one set of receiving equipment, reducing the cost where several readings are required. Readings can be initiated by time clock or by supervisory control or by other means; readout devices can be digital indicator, adding-machine-type printout, or automatic typewriter. Readings also can be punched on tape or cards for use with data-handling equipment.

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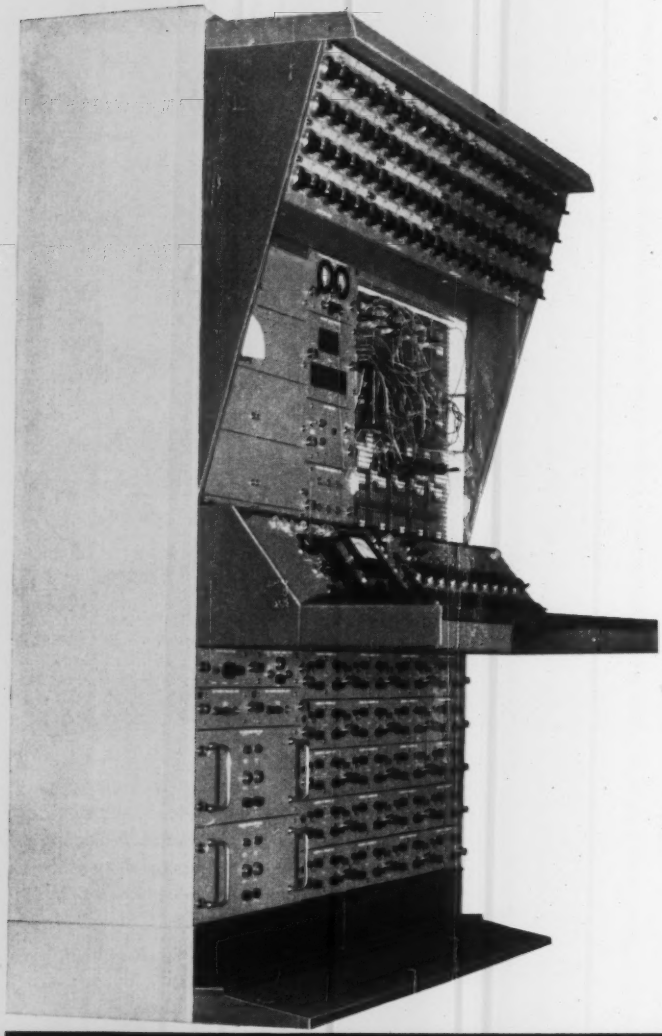

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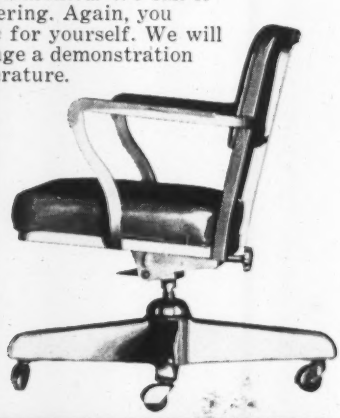

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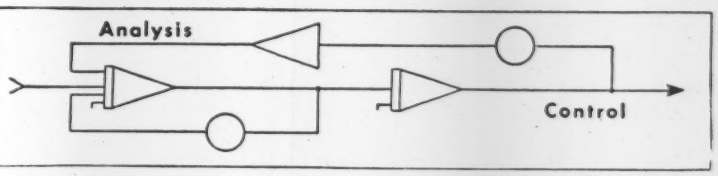

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Bits

This month we report that the Southeastern Simulation Council held a meeting at the Glenn Martin Company's Orlando plant last July, but we won't give many details because: (1) we are afraid some nuisance faced with such out-of-date info will ask what the "News" in the *Newsletter* stands for, and (2) we don't have many details! Lest the SSC feel slighted we will report their more recent activities in some detail in next month's *Newsletter*.

This month we devote most of our space to an only somewhat condensed version of *P. J. Hermann's* notes on the Midwestern Simulation Council's November meeting on that old standby "Combined Analog-Digital Techniques."

Good solid stuff!

Pieces

MIDWESTERN SIMULATION COUNCIL OF 3 NOVEMBER ON COMBINED A-D SIMULATION

The Midwestern Simulation Council met at the University of Illinois (at Champaign and Urbana) on 3 November 1958. Acting as hosts for the University were Professors *T. J. Dolan* and *W. J. Worley* of the Department of Theoretical and Applied Mechanics. About 40 members were present to discuss "Combined Analog and Digital Computing Techniques."

Before the meeting members of the Midwestern Council were taken on tours of the University computing facilities. Most prominent of these is the famous ILLIAC digital computer which, now obsolete, was for years one of the fastest computers in the world. The Electrical Engineering Department showed its PACE analog computer facility.

Meagher on Simulation on the Campus

Verne Larrowe (University of Michigan Willow Run Laboratories, Ypsilanti, Mich.) introduced *Dr. Ralph Meagher* (University of Illinois), who offered greetings and comments about simulation on the campus.

Much of what is done in the Engineering Departments could be called simulation, Dr. Meagher said, since really mathematical representation itself is a form of simulation. Analog computers have been used at various times at the University since 1945, including some of the mechanical integrator type. One, designed by *Professor Nordzieck*, is still in the Physics Building as a sort of show-piece. More recently a network analyzer was constructed, and a PACE general-purpose electronic analog computer has been installed.

Work on digital computers started about 1949 with the building of the large-scale ORDVAC computer, still in use at the Aberdeen Proving Ground. Next came the ILLIAC, still in use at the University. The ILLIAC has an arithmetic unit with addition time of about 90 microseconds and multiplication time about 300 microseconds. It's a simple, pure-binary machine with no redundancy of any kind. It has a Williams-type memory of 1024 40-bit words, supplemented by a drum memory of some 12,000 words.

The University offers no courses in simulation, as such, at present. There is, however, an increasing appreciation on the part of students of the importance of computers in the engineering world, and the time is coming when the engineering student will have to know electronic computers just as we expect him to know his slide rule today.

A one-semester introductory course in digital computer programming is offered, in which 250 students per year are becoming familiar with programming techniques. Numerical analysis is introduced in this course along with material on the solution of certain kinds of problems, particu-

larly differential equations. This course is followed by a more rigorous one in which numerical analysis is more strongly emphasized and in which detailed error analyses are made. In the Mathematics Department another course in numerical analysis is given which fringes on the use of computers, although no actual computer use is required.

The University offers a more complete program in computer design. A course called Logical Design of Automatic Computers is an introductory course for students in Electrical Engineering. This course is taken by about 100 students per year. Two other courses in Boolean Algebra are much more abstract, basic, and detailed and require two semesters to complete.

Dr. Meagher summarized by stating that though the University offers no degree in computers, it is clear that computers are about as basic today as the slide rule was 10 years ago.

Bob Dike (Caterpillar Tractor Company, Peoria, Ill.) asked whether other colleges of the University offered courses in computers.

"With perhaps one exception they do not. We have a *Mr. Miller* and *Mr. Isaacson* who have shown great interest in writing music with a digital computer. The technique is one which is pretty well understood now. Professor Isaacson, who was originally a chemist, has a part-time appointment in the Department of Music now and offers a course for music students. I don't think the class is very large since it is being offered for the first time."

Asked by *Howard Moos* (Caterpillar Tractor) about computer courses in the Business Administration Department, Dr. Meagher replied that such courses are being introduced this year. An IBM 650 will augment the ILLIAC, largely to satisfy the needs of the Business Administration people.

Robertson on High-Speed Computer

Dr. Robertson (U. of Ill., Electrical Engineering Dept.) next described the design concept for a new high-speed computer now under development by his department. Study of characteristics for the new computer began several years ago, and during the past year development has passed into what Dr. Robertson called the "model stage," with experimental units built and tested but construction of the actual computer not yet under way.

The following is a comparison between characteristics of the ILLIAC and the new computer:

	ILLIAC	New Computer
Word Length (Binary Digits)	40	53
Storage Capacity (Words)	1024	8192
Storage Access Time (Microseconds)	18	1.5 to 2.0
Shift Time (Microseconds)	16	0.1
Multiply Time (Microseconds)	700	3.5 to 4.0
Divide Time (Microseconds)	1,000	5 to 6

Internal storage will make use of magnetic cores and will be augmented with external storage in the form of magnetic drum and magnetic tape.

In general the overall increase in arithmetic speed is a factor of about 200 over that of the ILLIAC. We suggest that interested readers contact Dr. Robertson directly, as there are many novel tricks of computer logic involved which will be of interest to those who can understand them.

Peet on A-D and D-A Converters

The next speaker, *William Peet II* (Electronic Associates, Inc., Long Branch, N. J.) spoke on "Applications of Analog-to-Digital and Digital-to-Analog Converters."

There has been considerable interest in combined analog and digital simulation. Unfortunately most people know that there is a potential but do not know where or how best to use combined simulation. Apparently combined analog and digital simulation is a powerful tool, but it is not a panacea for all computing ills.*

In general, combined analog-digital simulation suggests itself for problems in two categories: Simulation of systems which in themselves are inherently both analog and digital (Military examples are ground radar systems, fire control systems, digital guidance systems, etc.); and those in which the accuracy exceeds that of analog computers while the speed requirements exceed the capabilities of the digital computers. (Examples are long-time simulation, generation of a function of two or more variables, precision resolving and multiplication over a wide dynamic range.)

The problem of determining how the simulation is going to be divided between the analog and digital computers is usually not difficult if the system to be simulated is itself made up of analog and digital components. The problem becomes more complicated, however, where the existing computer capabilities are exceeded.

An example of the latter is simulation of a missile flight. In present-day systems it is not uncommon to consider initial ranges of 100,000 feet and miss-distance on the order of one foot. This dynamic range is well beyond the capability of analog computers. In the same example there may be look angle changes up to 90°, yet the missile may respond to changes of 0.1°. To obtain the required dynamic range in this problem we must resort to tricks and thus lose something in the simulation.

When we consider a simulation using combined analog and digital equipment it may not be at all clear whether the combined approach is needed. EAI's engineers have developed a logical approach to the problem which they believe will enable them to decide whether a combined technique is feasible, and which will provide realistic hardware specifications:

1. Divide the problem into analog and digital portions.

2. Formulate the digital program. Make sure that it is possible to perform the digital computations in the time allowed.

3. Determine the required accuracy of the analog-to-digital conversion. The accuracy of modern analog computers is on the order of 0.1%. As we don't want to degrade the accuracy of the analog portion through the digital portion it is desirable to have the digital portion an order of magnitude more accurate than the analog. A compromise figure that EAI has found quite satisfactory is 0.025%. This is equivalent to about 12 binary digits in the conversion. In some cases it may be necessary to have converters giving up to 14 binary digits.

4. Determine tolerable loop time for one analog-to-digital conversion, digital computation, and digital-to-analog conversion. This is determined by the desired accuracy in the highest frequency com-

*First place, this month's "Understatement of the Issue" contest!

SPEAKING WITH EASE®

An up-to-the-minute report on computer technology prepared by the **Beckman/Berkeley** *engineering staff*

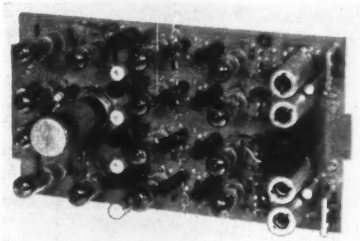
A New Look at Amplifier Performance

To select a well-built operational amplifier one must look a little further than traditional performance specifications. The reason is threefold. First, a comparison of performance specs often offers very little basis for choice. (This is a tribute to the advanced state of the art; manufacturers have now achieved most of the early primary objectives.) Second, many highly important characteristics are not—often cannot—be specified in so many words or numbers. And third, sometimes a performance spec can be "too good." This paradox occurs when a spec is unnecessarily high and achieved at the price of a hidden sacrifice.

In this situation the problem of evaluation is to find out exactly what is necessary in the area of specified performance then to search for evidence of other critical characteristics such as reliability, operating ease and maintenance time.

What Specs Mean in Terms of Performance

Open-loop Gain. In the past there has been a tendency to overestimate gain requirements. While a gain of 10^8 at dc is necessary for accurate integration, further gain does not appreciably improve performance and may cause trouble. Very high gain tends to compound stability problems—problems which can only be overcome by specialized circuitry which increases cost and complexity.



The EASE Model 1148 amplifier unit is representative of modern highly efficient and compact designs. Four amplifying channels are mounted on a single printed circuit board. Performance is somewhat superior to earlier models while cost per amplifier is scarcely one-half. Complete specifications are available on request.

Output Power. An amplifier capable of delivering 25ma current can drive seven 30K pots, an extraordinarily heavy load. Some models (including EASE amplifiers) will deliver full output current with less than a .01% increase in error due to distortion at frequencies up to 30 cps.

Input Grid Current. Low input grid current is necessary for accurate slow-speed integration. One micromicroamp of grid current flowing onto a 1μf integrating capacitor creates an output error that increases at 1μv per second. This means that a 30μμa grid current flowing during a computing period of ten minutes would produce a final error of approximately 20mv or .01%.

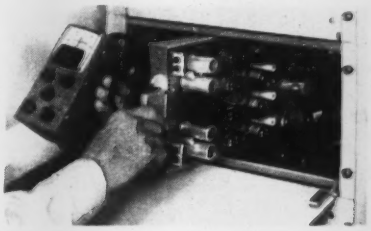
Under ordinary circumstances an attempt to reduce grid current below 30μμa is not wise. Other sources of error usually make it impossible to improve accuracy appreciably and available techniques have serious drawbacks. One method, using an electrometer tube at the input, is very costly and involves complicating the design with additional circuitry. Another method, using a blocking capacitor in the input circuit, requires added circuitry to prevent the accumulation of a charge under overload conditions.

Drift. DC drift is one region where amplifiers are continuing to improve. Since drift can always be corrected by zeroing, the drift specification is primarily an indication of how much routine adjustment an amplifier will require. Like input grid current, drift affects integrating accuracy. With a 1μf integrating capacitor and a 1M ohm integrating resistor, a 1μv offset creates an error that increases at 1μv per second. This means that a 30μv offset again produces a final error of about 20 mv or .01% during a ten-minute computing period. Amplifiers differ widely in the frequency of adjustment required, ranging from once every 3 or 4 hours to once a week.

The Unwritten Specifications

An amplifier's performance does not depend solely on its intrinsic characteristics. Surrounding circuitry has an enormous and usually unspecified effect. For example, if input and feedback resistors are given careful capacitive compensation one can achieve greater band-width, stability and the ability to drive high-capacity loads—sometimes 60 times the capacity permissible without compensation. Performance *within* a problem-solving circuit always merits investigation.

The time spent servicing and adjusting a battery of 30 to 100 amplifiers can be extremely expensive. For this reason an amplifier with few adjustments, a minimum number of components, less costly or less temperamental tubes and a high tolerance to power supply and temperature variations is often preferable to one with impressive performance figures. Conveniently accessible adjustments and rapid test procedures can also reduce service time when attention is necessary.



A 4-channel EASE 1148 being checked for performance with a specially-designed test unit. Three 4-channel units fit into 8¾" of rack space. Because of remarkably low drift, zero adjustment need be made only once a week under ordinary conditions. The test unit also checks open-loop gain, output current capacity and overload alarm.

C8

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ponents in the signal in the digital computer. As many as 150 analog-to-digital, digital-to-analog conversions per cycle of the highest frequency may be needed.*

EAI doesn't claim that the foregoing procedure is perfect, and will welcome suggestions for improvement.

The question of the required speed of the conversion units is important. The people at EAI feel that in most problems amenable to this simulation technique the most important time factor is the time required by the digital computer. The time spent in conversion is relatively small so that it is unnecessary to demand extremely high conversion rates. Conversion rates of the order of 100 per second are representative.**

It may be that phase relationships among variables must be maintained and simultaneous conversion required. In these cases sample-and-hold circuits are recommended with time-sharing of converters and sequential conversion of the variables.

A technique which hasn't been explored much to date and which offers advantages of economy and simplicity is multiplexing. Rather than using parallel analog-to-digital converters we can use multiplexing ahead of a single converter.

Bill showed slides of some EAI equipment with the following features:

20 channels of analog-to-digital conversion
10 channels of digital-to-analog conversion
Transistorized conversion circuits using multiplexing ahead of the analog-to-digital converter
Analog-to-digital conversion with 11 bits or 0.05% accuracy in resolution
Solid-state commutation ahead of the converter
Two-channel digital-to-analog converter chassis
Manual data insertion toggle switches
Digital zero switch on digital-to-analog converter

This equipment provides 30 channels of information conversion but, thanks to transistorization and multiplexing, it doesn't take up much room. Power consumption is ¾ kw.

In answer to questions by *J. D. Dunlop* (Allison Division, General Motors Corporation) Bill said that the equipment shown would be used with an IBM 701 computer and would be used on-line in the system with a PACE* analog computer with no intermediate steps in the process.

Wright on A-D Hardware

The next speaker was *Bob Wright* of Epsco. His talk centered more on the hardware aspects of analog-to-digital conversion. He had prepared his talk from the equipment manufacturer's viewpoint and discussed some of the practical restrictions which one might expect in purchasing the equipment and while operating it.

The manufacturer of equipment for linking analog and digital computers finds himself aligned with neither the analog nor digital computer manufacturer. To him the computers are nothing more than input-output devices—and not very good ones at that. The primary objective of most digital computer designers is to improve the internal circuits of the machine, not to provide good input-output facilities which the linkage equipment can tie into. On the other hand, analog computers are like pillows: they are pretty darned good low-pass filters.

The linkage manufacturer is rather like the fellow trying to drive a cart-load of perishables to market using a team of a mouse and an elephant. Somehow he's got to make this team work. An added difficulty is that he's often faced with not knowing where the market is. And potential users don't know the linkage equipment: even worse, often they don't know their own problems!

Two questions are uppermost in the minds of users and potential users of linkage equipment: what can they expect the equipment to do, and how can they be sure that it will? To answer these questions it is reasonable to talk about the fundamental notions involved in the circuit design and about some of the more general circuit requirements. Then perhaps users will be less inclined to come to the manufacturer asking for accuracies in the order of one part in infinity and drift of about one part in eternity.

Generally any analog-to-digital converter is predicated on a comparison of an unknown voltage against a known voltage. In Figure 1 something being generated internally is fed into a comparator amplifier and, when the comparator gives a signal, something is set into the "known" box which gives the digital reading.

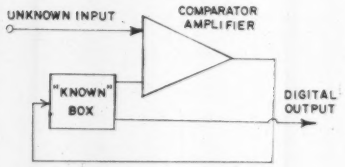


Fig. 1. Comparison technique.

One form of this device uses the known box to produce a *sawtooth wave* which rises at a known rate. The time required for the voltage to rise at the known rate to equal the unknown input voltage is measured by counting the pulses from a fixed-frequency oscillator which is turned off when the comparator amplifier reaches null.

Another technique is the process of *successive approximations*. This type of converter uses a sequence of weighted resistors and a constant-current generator. The current adder, controlled by switches, adds the currents switched into it, and a voltage is produced which is proportional to the currents being added. For a 6-bit converter of this sort, at the start of the conversion process a current, say 32i, is switched into the adder and the resulting voltage is compared with the unknown voltage. If the voltage is smaller than the unknown then the second current, 16i, is switched in. If the voltage is too large that current is switched off and the next current, 8i, is switched in. The process goes on until the least significant digit has been turned on and a comparison made. Both binary and decimal conversions can be made by changing the resistor cards controlling the current weighting. For example, it is possible to obtain currents i, 2i, 4i, 8i, 10i, 20i, 40i, 80i, and so on.

There are problems involved with the development of this conversion gadget. One is the question of the reference against which the conversion is to be made.

If you want relative accuracy you must tie the converter into the analog computer. If it's absolute accuracy you want, the comparator must be tied to an absolute reference voltage.

*Perhaps, but lower conversion rates can usually be bought with a bit of cleverness. See "Application of ADDAverter System in Combined Analog-Digital Computer Operation" by Jerry Greenstein, AIEE CP No. 56-842.—Ed.

**_Bill Wright_, Epsco, later expressed some reservations about this figure.

*Oh!—Ed.

In such cases the analog computer should be referenced to the absolute standard too.

An obvious source of error is the comparator amplifier; how closely can it detect null? Of course the conversion can be no better than the least significant bit, but a poor comparator amplifier could make it much worse.

Another factor is the absolute accuracy of the components in the converter. Epsco found that it was necessary to wind their own precision resistors to obtain the stable accuracy required over a long period of time and over temperature variations.

There are limits to the accuracies which you can expect. For example, if you could tie the computer back to a National Bureau of Standards source you could expect the source accuracy itself to be not much better than 0.05% over a long period of time. You cannot then expect the converter to be much better than 0.1%.

Another thing, and Bob stressed this point, there is always a point of conversion that is an indecisive voltage. If the voltage to be converted lies within the range of the least significant bit of the converter, the conversion process will not be able to make up its mind what the conversion is no matter what the accuracy of the comparator amplifier. For instance, in a 10-bit converter the least significant bit is 1 part in 1,000. This, the indeterminacy* accuracy, is 0.1%.

For the conversion of dynamic voltages the question arises: How little change in the input voltage must you have to be within the accuracy required for a given conversion? Let us take a 10-bit converter in which voltages are added in increments of full scale as ½, ¼, ⅛, etc., each increment taking 2 microseconds. For the 10-bit conversion, each voltage conversion will require 20 microseconds. To remain within an accuracy of 0.1% it can be shown that the input signal frequency can be no greater than 4 cps. This is not at all fast for an analog computer.

To get better conversion response you must speed up the conversion or resort to special techniques. One technique is to use sample-and-hold circuits. Sample-and-hold amplifiers can be developed which require only about 0.2 microsecond to sample a voltage. With such a circuit one can loaf in the conversion process so long as the conversion time doesn't eat into the digital computation time.

The equivalent input noise also must be considered. There are typically two sources. One is the conversion equipment itself. Such things as line voltage variation, drift, offset, and equivalent input noise generated by the components themselves are on the order of 10 to 20 microvolts. This is generally of little concern. The second source of equivalent input noise is noise in the input signal itself. Under normal operating conditions analog computers of Epsco's experience may be expected to have between 20 and 100 millivolts of noise on the signal. This is not out of the way at all. However, to digitize such voltages down into the microvolt region has no meaning at all. So, to users of conversion equipment: **"Please don't ask for more accuracy in the converter than you're actually going to get out of the equipment. Those last few bits of accuracy are not fooling the converter manufacturer, they're only fooling the user."**

Some comment should be made about the digital equipment to be used. *Program interrupt* is very important in obtaining real-time simulation. The present IBM 701 does not have program interrupt, the 709 does, and you can get it on the 704 as a customer option.

Multiple input-output buffers should be considered. Multiplexing can be used for analog-to-digital conversion, but most digital computers have only one input-output buffer. If you want to do true time-space techniques in which all the samples are to be taken simultaneously, or at least presented to the analog computer simultaneously, you must have multiple input-output buffers or develop rather esoteric storage techniques in the linkage equipment.

In summary, many things have been said that would probably be discouraging to users. The equipment is still far from perfect. A lot of work has been done on this linkage equipment, and there is a lot more to be done. It is important that the manufacturer and user get together to learn what to expect. More meetings like this and other Simulation Council meetings are needed.

Wood on Tank Simulation

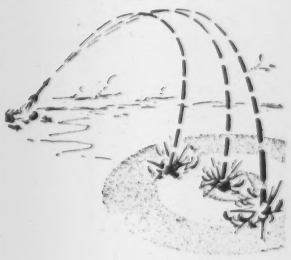
The next speaker was *Tom Wood* (Detroit Tank Arsenal, Detroit, Michigan). Tom's talk concerned the digital generation of a road function for military tank simulation.

"Why go to all the expense to do the job this way when it could be

*Not my word!—Ed.

ARE any new fields of computation opened up by the GPS High Speed Analog Computer?

YES, the statistical evaluation of the performance of systems perturbated by random noise can now be accomplished at high speed. With the system simulated on a



high speed computer such that the solution is carried out several thousand times faster than real time, samples of a random variable such as the miss distance of a missile system can be taken at rates up to 50 per second. Thus, sample sizes of several hundred can be taken in a few seconds' time.

GPS has a complete line of equipment to generate random noise for introduction to the system and to monitor the output. RMS values of random variables can be measured directly and complete probability distribution functions can be determined with statistical confidence in a matter of minutes.

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done by some other special-purpose equipment?" The answer is that the people at the Arsenal have investigated a number of different ways and decided that this particular method is the least expensive under the circumstances.

The people at the Ordnance Tank Automotive Command (Detroit Tank Arsenal) are setting up a large simulation of a military vehicle which will incorporate the road input to the vehicle and, also, will be capable of putting a man into the gun control loop. The object is to aid in the development of particular gun-control and gun-stabilization systems. A sketch of the system is shown in Figure 2.

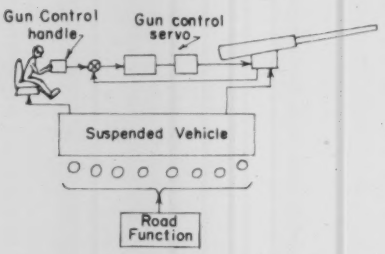

Fig. 2. Simulation of tank on road.

The vehicle suspension system has many outputs, the most important going to the man at the gun control handle. This in turn is connected to the gun-control system, which may or may not be space-stabilized. There are vehicle disturbances which come from the vehicle, some to disturb the gun and some the man.

Under development is an "integrated fighting compartment simulator." This is essentially a three-axis table which will receive outputs of the vehicle simulation and disturb the man in the gun control loop much as he would be disturbed in the actual vehicle. The gun control loop will then be closed through the gun controller in the simulator.

The difficult thing is to specify the kind of road that the tank will go over and the type of disturbances to be received by the tank. The requirements on the road function generator are that it generate 12 independent signals, be able to vary the simulated speed of the vehicle down the road, and have a 1% accuracy over the range of plus-or-minus 100 volts.

The difficulty in generating the road function is the 30:1 speed range of the vehicle. After trying other ways it was finally decided to use the available digital computer. It was concluded that it would be relatively easy to program the road function in the digital computer and control the changes in amplitude of the road and changes in the speed. The road function could be pre-stored and presented to the analog computer through a digital-to-analog converter.

The Arsenal has a Datatron 205 computer which is relatively slow in comparison with modern computers. The requirements of the road function generator are pushing its capabilities because at the tank speeds being simulated, it is desirable to present the analog computer with a road function value every 25 milliseconds. As the digital program developed so far requires 27 milliseconds, you can see that the limits *really* are being pushed!*

Specifications for the linkage equipment were written at the Arsenal and a contract was let to EAI.

In the converter there is the equivalent of a register in the Datatron 205. This is composed of a binary-coded decimal word of 10 digits plus sign. Two digits are used to describe the road for each wheel. Since the last two digits of the word are not used, each word describes the road for four wheels. Three words are required to describe the road for all 12 wheels of the tank. Multiplexing is used in the conversion train, and the converter is told where to send the information by a timer.

There is a digit in the Datatron computer called the "break point position." Its normal function is to stop the computer during debugging of programs when certain numbers are put into the break point position. Since the circuits were already available, it was decided to use this signal as the convert pulse to the converter. Because this break point signal is sensed when the command word is called into the register, it was necessary to provide a delay for the pulse to account for the time it takes to get the information from the memory up to the accumulator.

Another problem: the Datatron computer doesn't have a clock. The clocking technique and the computer program being used combined to produce what is not quite a true time slice of the road function, but something very close to it. The 25-millisecond computation time corresponds to about 30 mph and the technique will give reasonable accuracy at this speed. For simulated tank speeds of 5 to 8 mph, which tanks normally use in going across country, it is expected to give very good accuracy.

There is an adjustable means of smoothing the converter signal before it is fed into the analog computer.

The signal that is computed and put into the accumulator for conversion and fed into the analog computer is not the actual amplitude of the road function but is the derivative, dy/dx. This is multiplied by the velocity, dx/dt, to form dy/dt. One of the reasons for using this technique is that the amplitude or y-value of the road function is normally 150 times smaller than the maximum x-value. It is very difficult to generate the road function in any other way. You might consider magnetic tape techniques, but you will run into modulation and demodulation troubles every time that the simulated vehicle speed changes.

J. D. Dunlap (Allison Division, General Motors) asked if the output of the converter was a series of steps. Tom answered that the output of the converter holds the value into the amplifier during the digital computer time cycle.

Howard Moos (Caterpillar Tractor Co.) asked for Tom's definition of "economical." Tom said that this system cost $20,000 not including the computer, and that more than $20,000 had been spent in a research effort to determine other methods of generating the road function.

Crabtree on Tape Readers

Last speaker of the day was Ray Crabtree (University of Michigan, Willow Run Laboratories), who told about a number of applications of a digital tape-reader to analog computer operations, as developed by Ray and by *D. Y. Liang* at the Willow Run Laboratories.

Figure 3 shows a block diagram of an operational sequence of automatic analog computation. Data stored on the paper tape are converted into analog voltages and fed into the analog computer. The computer develops signals which are to be plotted on an x-y plotter. The function of the operational sequence system is to take data from the paper tape, compute results in the computer and plot the results on the

*Second place, UOTI contest.

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Heart of the system is the Bendix G-15 general purpose digital computer, which has proven its performance in well over 150 successful installations.

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A full 80 columns of numeric, alphabetic, or special character information can be accommodated using only the CA-2 as a connecting link between the card equipment and the G-15. Any column of the card can contain any one of the three types of information.

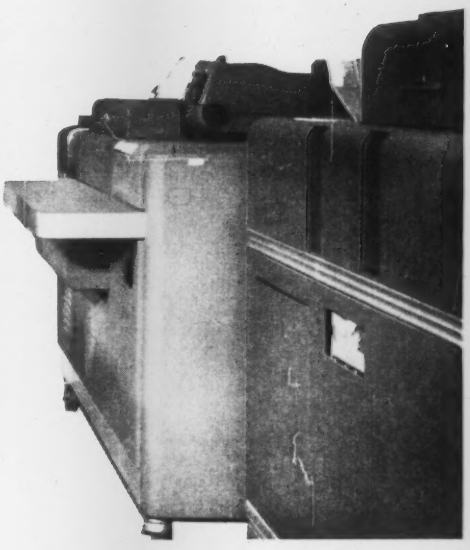
Three input-output units may be connected simultaneously . . . one for input, one for output, and a third for input or output. Data may be read or punched by standard card units, or printed by standard tabulators. All input and output is under complete control of the computer. Computation can proceed during the input or output cycle, thus assuring maximum over-all computing speed.

In addition to the CA-2, the computer's typewriter and paper tape equipment, and auxiliary magnetic tape storage units may be used for completely versatile input, output, and storage. Both power and space requirements of the complete punched card computer system are approximately half that of other systems of this type.

A system that includes the G-15 computer, the CA-2 coupler, two summary punches and a tabulator, leases for approximately half the price of a typical medium-priced system with similar capabilities.

Whether you are now using punched card or computing equipment, or if you are delaying such plans due to high costs, you will want to learn more about this inexpensive, efficient equipment. Detailed technical information on the G-15 and the CA-2 will be sent on request. Write to the Bendix Computer Division of Bendix Aviation Corporation, Los Angeles 45, California. Dept. J-11.

Bendix® Computer



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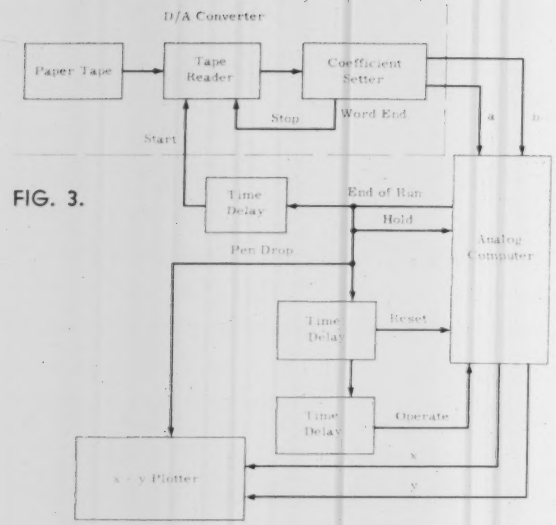


FIG. 3.

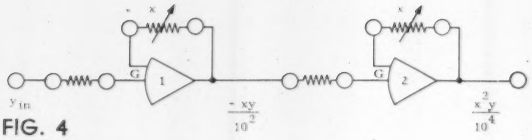


FIG. 4

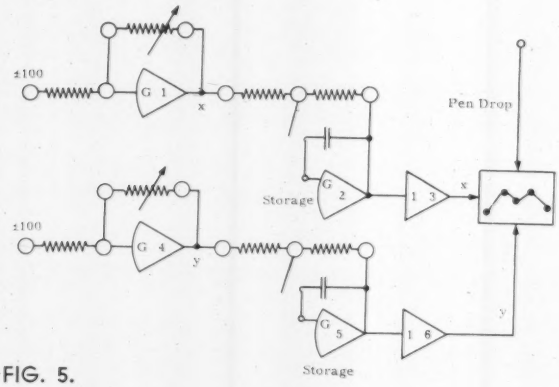


FIG. 5.

plotter, and to do this automatically. A number of control circuits are necessary to operate the computer, plotter, converter, and tape units in the proper sequence.

The digital-to-analog conversion unit can be used as a function generator also. A particular case is shown in Figure 4. The voltage, y, is fed into the amplifier and the feedback is controlled through the relay register in the amplifier feedback to be proportional to the other variable, x. The output is, then, in the case shown, proportional to the product of x and y.

Another application of the converter is shown in Figure 5. This is an automatic point or straight-line plotter using an x-y plotter. If the plotting pen is held up until the conversion unit has settled out on value, then the system operates as a point plotter. If the pen is in writing position all of the time, the plot is a straight-line plot of the data as indicated in the figure. Ray showed that, as long as the RC time constants in the hold or storage amplifiers (G_2 and G_5) are large enough so that the writing speed of the plotter is not exceeded, the plots are always straight lines. The two amplifiers are the familiar sample-and-hold type of operational amplifier.

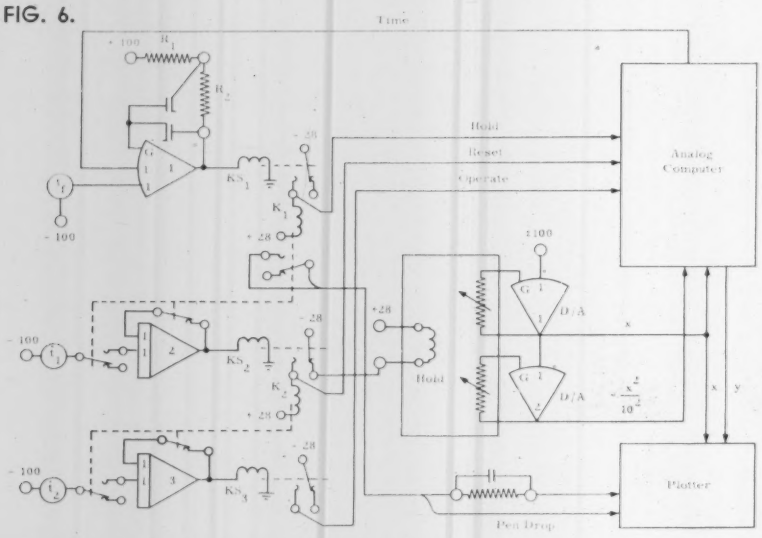
Ray listed four areas in which they have found applications for their converter:

1. Plotting points from punched tape data.
2. Plotting broken-line (straight-line) graphs from punched tape data.
3. Providing inputs to analog computers as shown in Figure 3.
4. Checking out function tables, diode function generators, or any large series of voltages which you might have on a problem to be run over a long period of time. The converter enables you to check a large number of voltages in a short period of time.

Ray then talked about the automatic computer control circuits for two (Fig. 6) and four variables respectively. These circuits receive the end-of-run pulse, put the analog computer in HOLD, drop the pen to plot the results, operate the analog computer reset switch, allow the D-A converter to step ahead, hold the system until the converter has settled to the new values, and then put the system into operation for the next computation.

This system has been used to plot as many as 120 separate data plots on standard 11″ x 17″ paper, all automatically once the punched data were started through the system.

FIG. 6.



SOUTHEASTERN S/C MEETING OF 11 JULY

About 30 people attended the 11 July 1958 meeting of the Southeastern Simulation Council at the Glenn Martin Company's plant at Orlando, Florida. We were interested to note that one of our Western Simulation Council charter members, *Floyd Nixon*, is now manager of Martin's Systems Analysis Department and welcomed the group on behalf of his company.

At this meeting *Dr. Ivan Rezucha* of IBM spoke on "How to Program Job-Shop Simulation on an IBM or Digital Computer." *Charlie Morrell*, *Jack Rudolph*, and *Saul Yochelson*, all of Goodyear Aircraft, described

ROYAL PRECISION

Here is the low-cost, desk-side electronic digital computer you need for general design and system optimization

Speeds optimum design of new products and equipment!

Operating from any convenient wall outlet, the compact, powerful LGP-30 will today furnish you with high-speed electronic computation wherever you need it . . . will eliminate tedious hand calculations . . . help you free up more creative time.

Combining large memory (4096 words) and stored-program operation, the LGP-30 gives you twice the capacity of any computer in its class, yet is by far the easiest to program in basic machine language. Simplified controls can be operated with only minimum computer experience. Answers are printed out directly—require no deciphering. Best of all, even with these many unique advantages, the LGP-30 is the lowest-priced complete computer you can buy. What's more, auxiliary high-speed input—output equipment is available for system expansion.

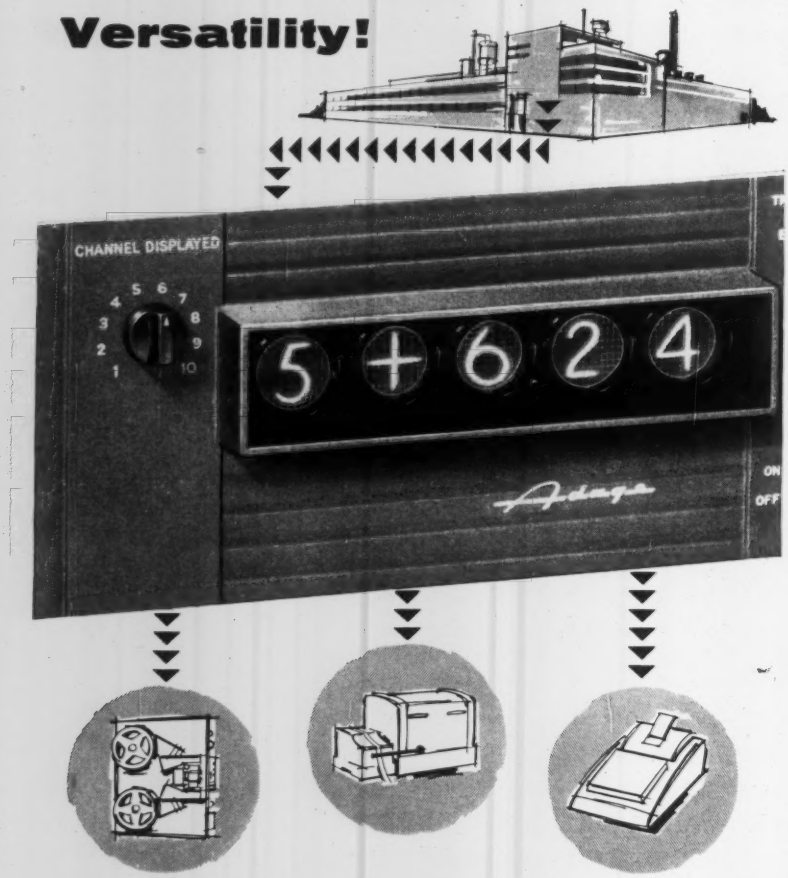
No expensive installation or air-conditioning required. Customer training is free. An extensive library of programs and sub-routines is available—as well as membership in an active users organization. Sales and service facilities are maintained coast-to-coast.

For further information and specifications, write Royal McBee Corporation, Data Processing Division, Port Chester, N. Y. In Canada: The McBee Company, Ltd., 179 Bartley Drive, Toronto 16.

• data processing division

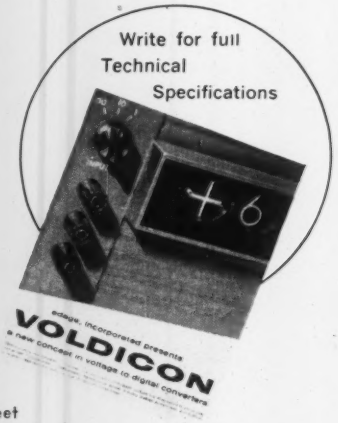
For more information circle **72** on inquiry card.

New Adage Converters Offer Unlimited Versatility!



Unlimited Versatility? — a large statement. But the facts back it up! Voldicon will translate inputs from any source into any storage device.
Name your input: thermocouple, strain gage, telemetry data, analog computer (there are too many possibilities to list here) . . . Name your output: magnetic tape, tape punch, printer, digital computer . . . Voldicon will handle any combination.
Whatever your needs there is a Voldicon model designed to answer your problems . . . well within your budget.

NEW VOLDICON FEATURES:
- **New Transistor Design**
- **New Speed** — up to 10,000 separate conversions per second
- **New Accuracy and Reliability**



Adage
INCORPORATED

Department IA-4, 292 Main Street
Cambridge 42, Mass.

For more information circle **73** on inquiry card.

SIMULATION COUNCIL —CONT.

different aspects of the Martin GEDA installation. Details are available in Goodyear's Engineering Report 8837, "A Large-Scale Digitally Programmed GEDA Analog Computer for the Martin Company," which I am sure Charlie would be happy to send all who are interested. In the last talk before lunch *John M. Carter* (California Technical Industries) described their Three-Axis Flight Simulator, installed at Martin, and showed a moving picture of the table in operation.

After lunch there was a conducted tour of the Martin analog and digital computer facilities, and after dinner Floyd Nixon told of the work of this Martin Computer Center on specific problems.

That, *Ed Holmes* (E. G. Holmes & Associates, Atlanta, Ga.) informs us without further explanation, ended the meeting!

He Came Thisaway!

Art Vance to Hughes Aircraft, Malibu, California.

He Stayed Put (geographically speaking)

Eric Weiss to Rheem Manufacturing, R&D, La Jolla, Calif. (Yes, we've got the right Eric this time. He told us himself.)

Computer Events

Eastern Simulation Council

Date: 20 April, 1959
Place: University of Virginia and Sperry-Piedmont, Charlottsville, Va.
Subject: "Computers in Analysis and Control."

For further info write Sidney Korn, Sylvania Electronic Systems. 100 First Ave., Waltham 54, Mass.

Central Simulation Council

Date: 11 May 1959
Place: Kansas State College, Manhattan, Kansas
Subject: "Non-Linear Control Systems"

For further information write Charles Halijak at Kansas State College.

Circle **74** on inquiry card. ⟶

"COMPUTER PROGRAMMING *at SDC is a fundamental discipline rather than a service. This approach to programming reflects the special nature of SDC's work—developing large-scale computer-centered systems.*

"Our computing facility is the largest in the world. Our work includes programming for real time systems, studies of automatic programming, machine translation, pattern recognition, information retrieval, simulation, and a variety of other data processing problems. SDC is one of the few organizations that carries on such broad research and development in programming.

"When we consider a complex system that involves a high speed computer, we look on the computer program as a system component—one requiring the same attention as the hardware, and designed to mesh with other components. We feel that the program must not simply be patched in later. This point of view means that SDC programmers are participants in the development of a system and that they influence the design of components such as computers and communication links, in much the same way as hardware design influences computer programs.

"Major expansion in our work has created a number of new positions for those who wish to accept new challenges in programming. Senior positions are open. I suggest you write directly to Mr. William Keefer at the address below. He is responsible for prompt response to your correspondence."

T. B. Steel

Senior Computer Systems Specialist

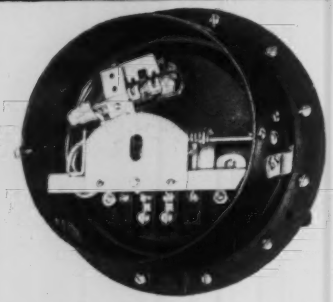
11-97

SDC

SYSTEM DEVELOPMENT CORPORATION

2417 COLORADO AVENUE, SANTA MONICA, CALIFORNIA

new instrument



FM APPROVED

LOW PRESSURE DIAPHRAGM CONTROL

For Air or Gases

This FM approved (Mercoid Type PG) control can be used three different ways; for positive pressure; negative pressure (vacuum); for differential pressure or vacuum.

OPERATING RANGE 1.0″ to 30.0″ (H_2O)

FIXED DIFFERENTIAL (Sensitivity)
When operating point is set at

Low	Med.	High
0.6″	0.8″	1.0″

MAXIMUM PRESSURE 20 psig

Equipped with Fairprene diaphragm, external adjustments, hermetically sealed mercury switch—case made of heavy gauge steel (NEMA 1)

Available fully automatic or semi-automatic with manual reset.

Write for Bulletin PG to The Mercoid Corporation, 4231 Belmont Ave., Chicago 41.

FM APPROVED

HIGH TEMPERATURE LIMIT CONTROL

Mercoid Type MX-51R for use with dryers, ovens, furnaces, etc. This adjustable indicating type high temperature limit control is actuated by a coiled bimetal element to result in a normally closed mercury (tube type) switch opening in event the supervised temperature reaches the preset limit point. A manual reset knob is arranged to reset mercury switch after high temperature operation and normal temperature restoration.

Operating Range (adjustable) 50-650° F. Minimum Differential 20° F. Electrical Rating 10A. 115V. 5A. 230V.

Has independent adjustments for setting both high and low operating points; visible calibrated dial; sealed mercury contact, reversible mounting flange. Case made of heavy gauge steel (NEMA 1)

Write for Bulletin SEB-51 to The Mercoid Corporation, 4231 Belmont Avenue, Chicago 41, Illinois.

SPECIFY
MERCOID® CONTROLS

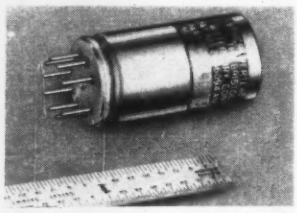
For more information circle **75** on inquiry card.

new instruments

FOR FURTHER INFORMATION USE THE FREE ORDER CARD ON PAGE 615

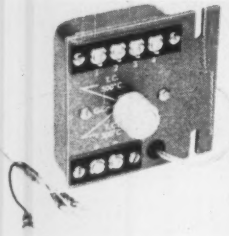
SYNCROVERTER CHOPPERS

New sub-miniature DPDT Syncroverter Chopper has excellent tracking, and resistance to shock and vibration, and features contact rating from dry circuit to 100 v; phase angle is virtually unaffected by temperature extremes from −65°C to +125°C.—*The Bristol Co., Waterbury 20, Conn.*



For more information circle **172** on inquiry card.

READOUT ACCESSORY

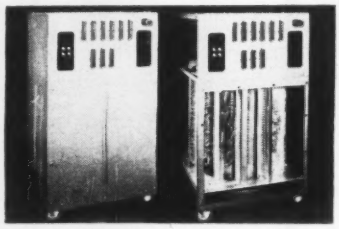


New Temperature Readout Accessory for recording column or sample inlet temperatures directly on gas chromatograph charts is designed for installation on one-millivolt recorders. The unit consists of a switch box and two iron-constantan thermocouples, one for use as a reference and the other for sample compartment temperature readout.—*Beckman/Scientific and Process Instruments Div., 2500 Fullerton Rd., Fullerton, Calif.*

For more information circle **173** on inquiry card.

MAGNETIC STORAGE DRUM

New high-capacity Magnetic Storage Drum, Type 1016-A, for vertical mounting, features storage of approximately 1,500,000 bits; drum surface T.I.R. runout of 0.0001″ or less; and a recording surface coated with "Grimaco" grindable magnetic oxide coating. Drum dimensions are 10″ dia x 16″ long.—*Bryant Chucking Grinder Co., Springfield, Vt.*



For more information circle **174** on inquiry card.

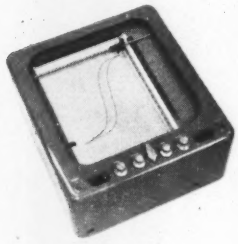
SURFACE-TEMPERATURE METER

New Pyrotem is an inexpensive instrument for making ± 2% full-scale-accuracy temperature measurements. Two types are available: (1) an automatically compensated Model DTF for ambient temperature, and (2) a non-compensated type, Model EFT, for relative temperature readings. Ranges are 0-300°, 0-450° and 0-650°F for Model DTF and 0-200°C for Model ETF. Ultimate temperature response is attained in 3 to 10 sec.—*Royco Instruments, Inc., 874 Fabian Way, Palo Alto, Calif.*

For more information circle **175** on inquiry card.

X-Y RECORDER

New HR-92 X-Y Recorder is used for computer readout and for plotting stress vs strain; magnetic material, tube and semiconductor characteristics; pressure vs temperature; speed

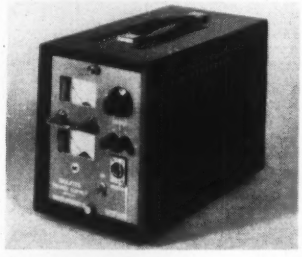


vs torque; or any other two related variables. Use of self-balancing potentiometer servos assures ½% accuracy and drift-free performance at available sensitivities of up to 1 mv/in.—*Houston Instrument Corp.*, 1717 *Clay Ave., Houston 3, Texas.*

For more information circle **176** on inquiry card.

ISOLATED POWER SUPPLY

New portable Model 21 Power Supply, with output isolated from line voltage and line ground, uses specially shielded transformer and unique feed-



back isolation circuits which permit precise and dynamically accurate results when used in connection with bridge-type transducers such as strain gages, accelerometers, resistance thermometers and pressure gages.—*Moeller Instrument Co., Electronics Div., 132nd St., & 89th Ave., Richmond Hill 18, N. Y.*

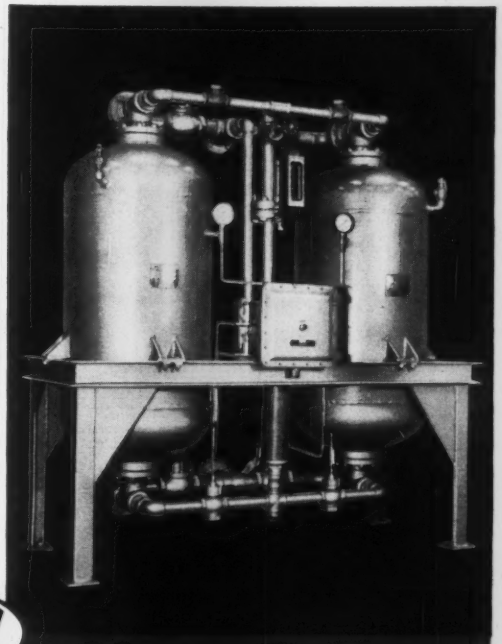
For more information circle **177** on inquiry card.

SINGLE-AXIS ACCELEROMETER

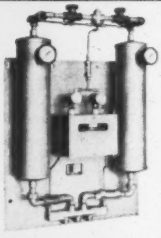
New single-axis Accelerometers D1754-01 and D1756-01 utilize a spring mass system sensitive to linear accelerations along an input axis, but insensitive to accelerations normal to that axis. They are ideally suited to missile inertial guidance applications in which high-vibration environments are encountered. Typical characteristics for both are: Voltage—3.4 v; frequency—4000 cps; range—±10 g; frequency response—flat to 220 (for D1754-01), and flat to 120 (for D1756-01).—*Kearfott Co., Inc.*, 1500 *Main Ave., Clifton, N. J.*

For more information circle **178** on inquiry card.

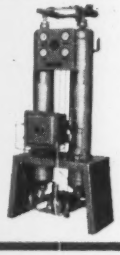
some remarkable **FACTS** about the **TRINITY**



Heat-Les desiccant **DRYER**



Heat-Les dryers are available in a wide range of capacities to meet all industrial and military needs.



1. REJECTS OIL—Eliminates the need for accessory oil filters and ensuing replacements of desiccant or filter cartridges.

2. LOWER INITIAL COST—Original equipment costs savings up to 50%, depending upon installation requirements.

3. LOWER MAINTENANCE COSTS—No heaters to service. Few moving parts. Designed for maximum life, minimum service requirements.

4. COMPLETELY AUTOMATIC—Requires no attention.

5. DEWPOINTS AS LOW AS —180° F—Standard guarantee—100° F at line pressure. Actual dewpoints below range of usual measurement.

Here's a working phenomenon so remarkably simple, yet so effective, you must see it to believe it. The Heat-Les Dryer is the practical answer to all industrial dynamic dehumidification needs.

WRITE FOR COMPLETE DETAILS...

Heat-Les Dryers are available in a wide range of sizes to meet practically all requirements, and are designed to operate at 30 to 6000 psig.

TRINITY

Heat and Heat-Les reactivated dryers.
Complete air supply and purging systems.

TRINITY EQUIPMENT CORPORATION, CORTLAND, NEW YORK

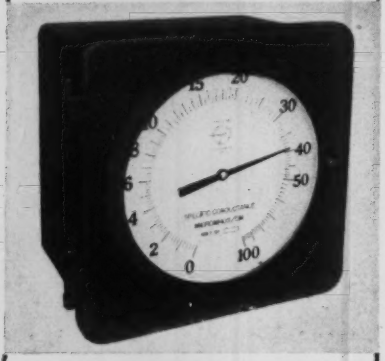
For more information circle **76** on inquiry card.

Self-Balancing

INDICATOR-CONTROLLER

Type RI

For Measurement of Electrolytic Conductivity



A COMPACT, self-balancing instrument, the RI Indicator-Controller is used for the measurement and control of solution concentrations in industrial processes not requiring recording. The exceptional flexibility of the instrument permits its use for any measurement of electrolytic conductivity from the very highest resistance of pure water and condensed steam to the low resistance of concentrated solutions of acids, alkalis and salts.

FEATURES:

- True AC Wheatstone Bridge.
- Large easily read scales.
- Plug-ins for automatic or manual temperature compensation.
- Self-balancing, responds immediately to any change in solution conductivity.
- Available as a multi-range instrument for laboratory use, replacing manual balance bridges.
- Many types of control accessories available.

Industrial Instruments

Write for detailed literature

Industrial Instruments Inc.

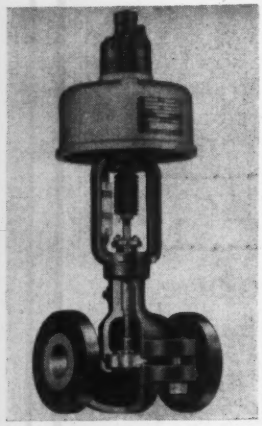
89 Commerce Road, Cedar Grove, Essex County, N. J.

For more information circle **77** on inquiry card.

NEW INSTRUMENTS

SPLIT-BODY VALVES

New line of split-body Control Valves features large flow capacities and face-to-face dimensions based on ISA standards. All major components such as topworks, valve bodies, line



flanges, plug, and seat rings are of unitized construction, making it possible to develop 432 different valve combinations from a single split-body, and enabling users to keep plant inventories to a minimum.—*Kieley & Mueller, Inc., 64 Genung St., Middletown, N. Y.*

For more information circle **179** on inquiry card.

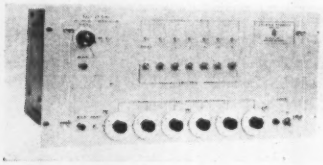
COATINGS FOR THERMOWELLS

New plastic or glass Coatings for the complete line of thermowells include Kel-F for applications up to 300°F; Teflon up to 500°F; Vinyl for corrosion resistance at lower temperatures; and a glass coating (between 0.040" and 0.060" thick) for mineral- and organic-acid service below 450°F, and alkaline service below 12 pH and 212°F.—*Trinity Equipment Corp., Cortland, N. Y.*

For more information circle **180** on inquiry card.

COUNTER SCANNER

New Model DY-2513 Counter Scanner automatically records the information registered in up to six electronic counters on a single Hewlett-



Packard Model 560A digital recorder. It scans data sources having up to five decimal places (up to eight digits on special order). Counter display times are adjusted by a front-panel control on the scanner.—*Dymec, Inc., 395 Page Mill Rd., Palo Alto, Calif.*

For more information circle **181** on inquiry card.

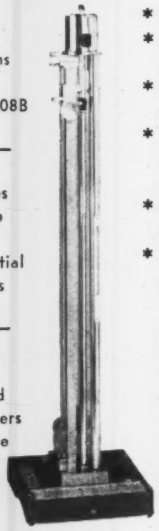
PRECISION—MERCURIAL BAROMETERS—MANOMETERS

AVAILABLE WITH ANY OR ALL OF THESE FEATURES:

Conforms to Spec. Mil-B-4308B

Measures Absolute or Differential Pressures

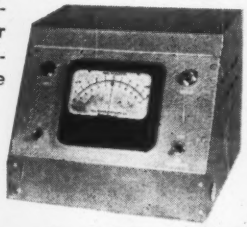
Primary Standard Barometers Available



31" Type A-1 Barometer

- Range 0-31", 0-62" and 0-105" inches of mercury.
- Complete Temperature and gravity compensation.
- Direct true pressure readings with accuracy guaranteed to .02% of full scale.
- Manual Sighting or Photo Electric Scanner indicating pressure changes of less than 0.01 mm mercury.
- Stop-bar mechanism for production testing at predetermined points.
- Choice of scale graduations: inches, millimeters, millibars, altitude or special.

Used by the U. S. Air Force, and instrument manufacturers for the calibration of Altimeters, Air Speed Indicators, Automatic Pilots, Altitude Switches, Thrust Meters, Machmeters, Air Data Computers, etc.



Amplifier for Photo Scanner

Phone Hickory 9-5454

For more information or special application write to:

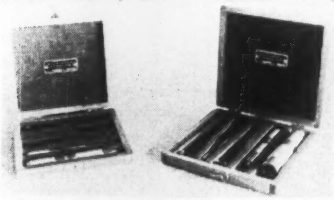
THE **HASS INSTRUMENT** CORPORATION

6173 BRANCH AVENUE **WASHINGTON 23, D. C.**

For more information circle **78** on inquiry card.

TOOL KIT

New kit, containing male and female assembly tools and male and female tweezers, is designed for the

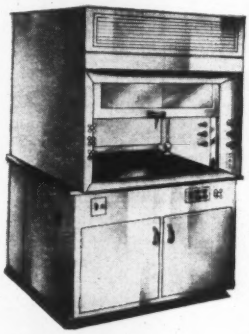


specific purpose of proper handling and assembly of instrument bearings. —*Baker Co., Inc.*, 106 *Granite St., Biddeford, Maine.*

For more information circle **182** on inquiry card.

FUME HOODS

New Fume Hoods have electronically-operated sashes and baffles.—Cata-

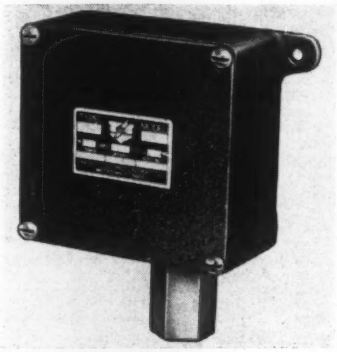


log DH-3 gives details.—*Duralab Equipment Corp.*, 998 *Linwood St., Brooklyn* 8, *N. Y.*

For more information circle **183** on inquiry card.

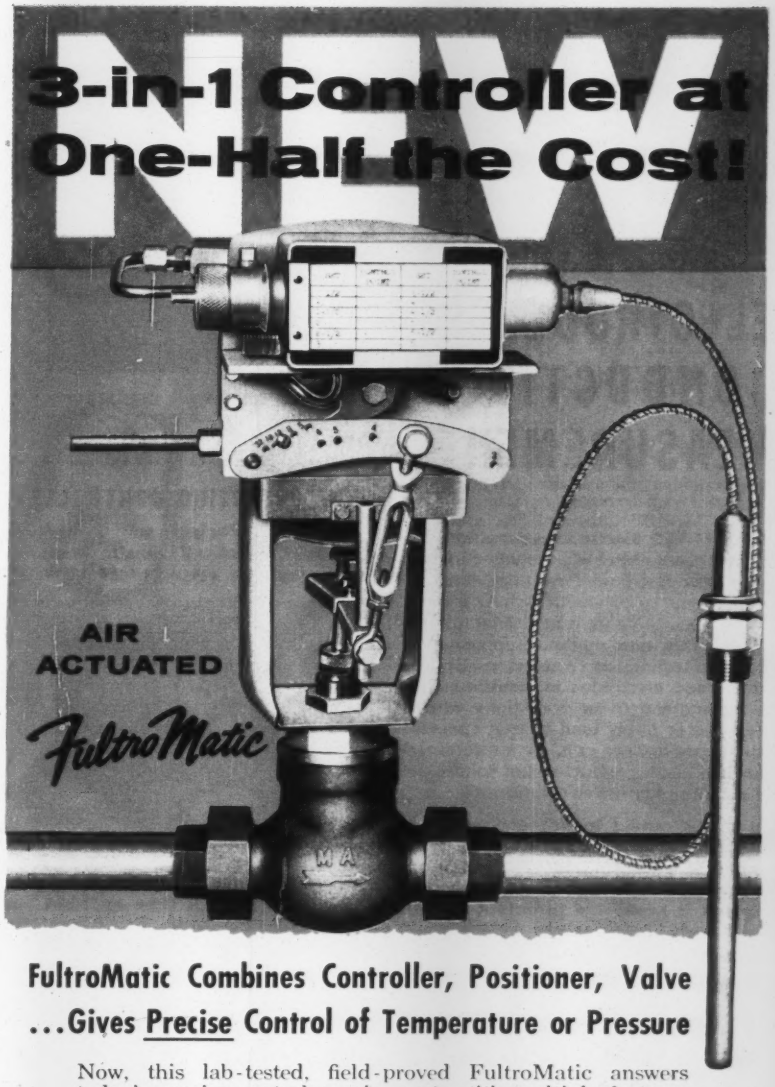
PRESSURE CONTROLLER

New Models 670 and 680 have been added to the Type J11 Pressure Control series. Model 670 ranges from 50 to 1000 psi and Model 680 from



100 to 1700 psi. Both models have a maximum bellows pressure of 3500 psi. The bellows is constructed of stainless steel with brass pressure connections.—*United Electric Controls Co., 79 School St., Watertown, Mass.*

For more information circle **184** on inquiry card.



FultroMatic Combines Controller, Positioner, Valve ...Gives Precise Control of Temperature or Pressure

Now, this lab-tested, field-proved FultroMatic answers today's precise control requirements with multiple features never before available in one unit . . . *at about half the cost of two- and three-unit systems!*

- **Improved accuracy** with smaller, faster-responding element.
- **Positive valve positioning** by feedback action; no overshoot.
- **Adjustable proportional band** easily changed on the job.
- **Simplified settings** with knob, indicator, arbitrary scale.
- **Field reversibility:** control action quickly changeable.
- **Easy to install:** place valve in position, mount bulb, connect air.
- **Low maintenance:** rugged design for trouble-free service.

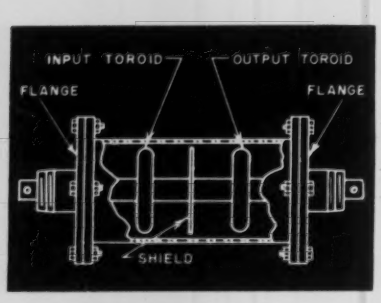
FOR COMPLETE FULTROMATIC SPECIFICATIONS, WRITE FOR BULLETIN GL-755

Mr. Controls

Robertshaw-Fulton CONTROLS COMPANY

FULTON SYLPHON DIVISION • Knoxville 1, Tennessee

For more information circle **79** on inquiry card.

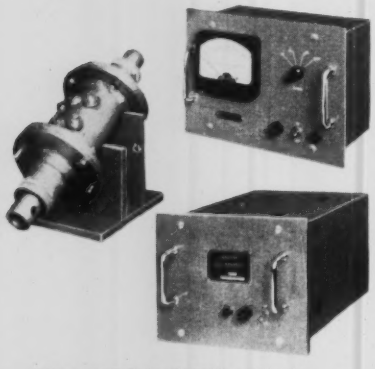


ELECTRODELESS CONDUCTIVITY MEASUREMENTS

A PATENTED electrodeless method for measurement of electrolytic conductivity with instrument readings directly proportional to conductivity over a wide range is available from Industrial Instruments. This **new** method supplements standard techniques (Wheatstone Bridge circuit and electrodes in solution) and is recommended for conditions where presence of fibers tend to clog conventional conductivity cells, or for abrasive slurries, highly conductive hot solutions, or extremely corrosive solutions.

Input and output toroids are mounted on flow-type cells. Input toroid is connected to a transmitting unit operating in high audio frequency range. Receiving unit is connected to output toroid. The liquid to be measured links the two toroids.

Available to meet explosion-proof requirements and with provisions for automatic or manual temperature compensation. Also available with recording instruments.



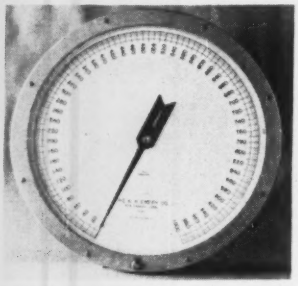
For complete details write to . . .

Industrial Instruments Inc.
89 Commerce Road, Cedar Grove, Essex County, N. J.

For more information circle **80** on inquiry card.

19½" DIAL INDICATOR

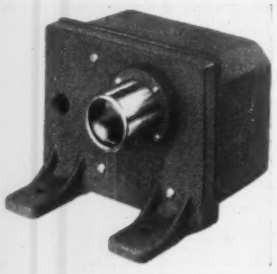
New 19½" Dial Indicator takes pressure readings with increased accuracy. Various scale graduations are available.—*A. H. Emery Co., Pine St., New Canaan, Conn.*



For more information circle **185** on inquiry card.

PHOTOELECTRIC CONTROLLER

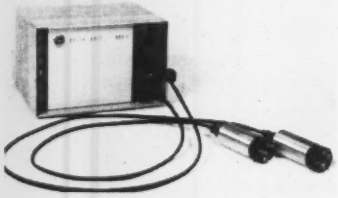
New BM1 Photoelectric Controller, utilizing a cad-cell sensing element with magnetic amplifier requires 10 foot-candles minimum light with 0.04 sec minimum dark time and 0.04 sec minimum light time. Relay contacts are DPDT, silver cadmium oxide, rated 10 amps at 115 vac, non-inductive load.—*Autotron, Inc., P.O. Box 722Q, Danville, Ill.*



For more information circle **186** on inquiry card.

CAPACITIVE ANALOG TRANSDUCER

New Model 902-1 Series Delta Unit is a general capacitive displacement measuring system for vibration amplitude, shaft runout, displacement of low force elements, and many other static and dynamic phenomena with an analogus voltage output. Input capacity range is 1 to 50 mmf usable, 5 to 20 mmf optimum, each side to ground; output signal range is ±30 v max, ±15 v typical.—4-page data sheet contains details.—*Decker Corp., 1361 Frankford Ave., Phila. 25, Pa.*



For more information circle **187** on inquiry card.

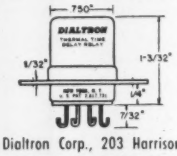
by DIALCO®

Hermetically Sealed

Rugged—built to meet conditions of

high altitude
high vibration
high temperature

DIALCO RELAYS exhibit no resonance from 5 to 1,000 CPS at 10 G's; are not damaged by 50 G's shock; are fully compensated for temperatures from −65° C to + 125° C.
Available in delays from 1 to 300 seconds; heater voltages up to 150 V. interchangeable on DC or AC of any frequency with a power drain of 4 watts. SPST normally open or normally closed contacts are rated at 6 amps at 115 V. AC or 3 amps at 28 V. DC resistive.



SUB-MINIATURE
Lightweight (3/4 oz.)
Standard 7-pin plug-in or solder terminals with mounting flange

Dialtron Corp., 203 Harrison Pl., Brooklyn 37, N. Y.

☐ Send data on Thermal Time Delay Relays to:
Name
Position
Company
Address

DIALTRON CORP.
203 Harrison Pl., Brooklyn 37, N. Y.
HYacinth 7-7600

For more information circle **81** on inquiry card.

MOISTURE BALANCE

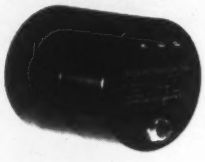
New and improved Moisture Balance, for fast and highly accurate determinations of moisture content in a wide variety of materials, features a

built-in autotransformer for automatic voltage regulation and more convenient temperature control, and a magnetic damper which reduces pan vibrations and speeds weighings.—*Central Scientific Co.*, 1700 *Irving Park Rd., Chicago* 13, *Ill.*

For more information circle **188** on inquiry card.

PRESSURE TRANSDUCER

New Pressure Transducer Type 4417, made specially for the remote indication of sea water depth, consists basically of a pressure sensing capsule element which actuates a preci-



sion wire-wound potentiometer. It employs a patented "angle-wipe" potentiometer, meaning that the potentiometer is at an angle to the direction of motion of the platinum-alloy wiper wire. The hermetically-sealed section, containing the wiper and potentiometer winding, is evacuated and partially filled with silicone oil.—*Colvin Laboratories, Inc.*, 360 *Glenwood Ave., East Orange, N. J.*

For more information circle **189** on inquiry card.

FUEL FLOW INDICATOR

New Aviation Fuel Flow Indicator, Type 9807-04, clearly displays flow as received from transmitter. Con-

forms throughout to MIL specs. Can be supplied with 28-v lighting circuit if required.—*John Oster Mfg. Co., Avionic Div., 1 Main St., Racine, Wis.*

For more information circle **190** on inquiry card.

BREEZE BELLOWS

Because BREEZE Bellows are job engineered for the most exacting applications, they insure high performance and long life. BREEZE offers a wealth of experience in weldable alloys such as Iconel X, titanium, Ni-Span, Hastelloys and Stainless steels. BREEZE Bellows solve tough problems in instrumentation, fuel regulation, pressure switches and expansion joints, hot air ducting, pressure surge tanks, packless valves, oscillating and rotating shaft seals, atomic and nuclear reactors.
We invite your inquiries.

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For more information circle **82** on inquiry card.

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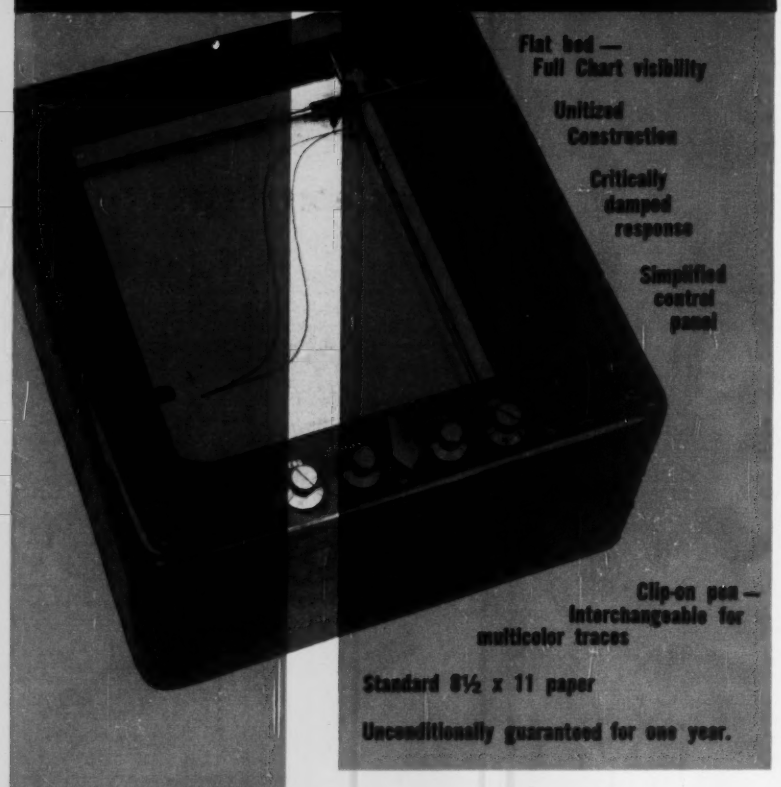
7318 South Chicago Ave. • Chicago 19, Ill.

For more information circle **83** on inquiry card.

HR-92 X-Y
RECORDER



RUGGED "All Purpose" X-Y RECORDER

The HR-92 is a null-seeking servo-type plotter designed to draw curves in Cartesian coordinates on regular 8½ x 11 graph paper. It employs conventional chopper amplifiers, 2-phase motors and a potentiometer rebalance. Reference voltages are furnished by mercury cells. Control panel has zero set and continuously-variable attenuator for each axis. Separate standby and power switches are provided. The two axes are electrically and mechanically independent. By moving an internal jumper lead, a high impedance potentiometer input can be made available.

SPECIAL FEATURES:

- Amplifiers easily removed if servicing ever becomes necessary. Electrical connections all contained in two plugs for each amplifier.
- Each amplifier channel (including transformer power supply) independent of rest of system.

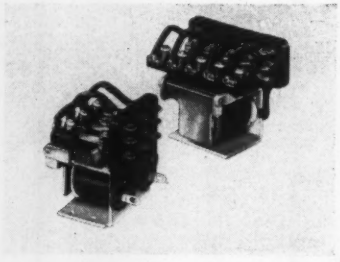
WRITE FOR:
New X-Y Recorder Circular #717-3 showing complete specifications and photographs.

houston instrument corporation
1717 Clay Avenue · Houston 3, Texas
CA 5-6964

For more information circle **84** on inquiry card.

POWER RELAY

New Type U general purpose Power Relay has single coil construction, employing box-type magnetic field. Contacts are rated singly at 10 to 25 amps, 110 vac, non-inductive. Maxi-



mum contact pressures are 35 grams each. Parts are silicon iron with copper shading washers. D-c relays incorporate high-quality annealed iron. —Bulletin U contains details.—*Comar Electric Co., 3349 Addison St., Chicago 18, Ill.*

For more information circle **191** on inquiry card.

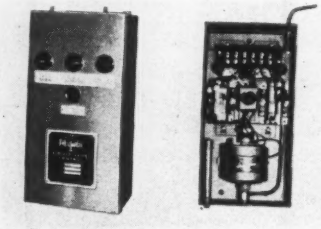
DIRECT-READING TANK GAGES

New direct-reading dial-type automatic Liquid Level Tank Gages Fig. 268V (with a vertical reading dial) and Fig. 268H (with a horizontal reading dial) are for use on small above- or underground tanks operating at or near atmospheric pressure. They feature a direct positive linkage between the float and dial indicator and an aluminum welded float. Installation is through a 3" pipe coupling.—*The Vapor Recovery Systems Co., Compton, Calif.*

For more information circle **192** on inquiry card.

LIQUID LEVEL CONTROLS

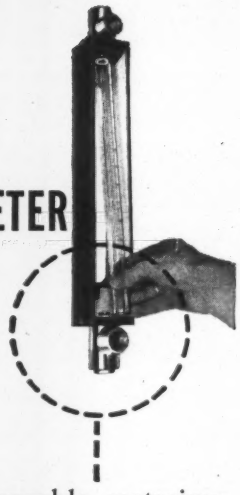
New Series 1800 Liquid Level Controls, for pressure ranges from 0.02 to 100 psi and to 30" vac, (actuated by a pressure element connected through tubing transmission lines to



an "Air Bell" pick-up device located in the tank at the approximate level where alarm or activation is desired), can start or stop a pump, open or close a solenoid valve, and with an additional relay permits the use of one device (siren, bell, etc.) with any number of controls.—*Petrometer Corp., 43-22 Tenth St., Long Island City 1, N. Y.*

For more information circle **193** on inquiry card.

NEW FULL-VIEW® ROTAMETER



Interchangeable metering tubes snap in and out . . . in seconds! It's that easy to change range or to service the new Brooks Series 1112 Full-View Rotameters.

A stainless steel leaf spring (entirely isolated from the process fluid) holds the tube perfectly in position, yet allows removal with just a simple up-and-out movement. No tools necessary.

Special O-ring construction and tube adapter assemblies make this time-saving convenience possible. Up to four different size metering tubes may be interchanged in a single case by merely changing adapters.

Like all Full-View Rotameters, the new Series 1112 features Brooks' dowel-pin, side-plate case construction. Thoroughly proven in service, this practical construction gives the meter case rigid strength, protects the glass metering tube from all line strain.

For More Information, Request Design Specification Sheet SS-111-2

BROOKS ROTAMETER COMPANY

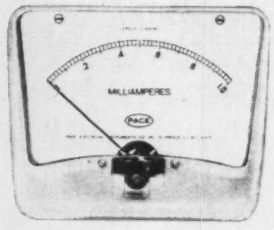
459 J STREET, LANSDALE, PA.

S.A. 1937

For more information circle **85** on inquiry card.

ACRYLIC-CASE METERS

New clear acrylic Meter Case consists of a crystal-clear window with a frosted white body. The latter can be painted to match any color equipment by simply spraying with acrylic lac-

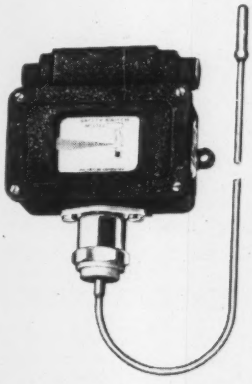


quer. The new line is currently available in three models: Model 25-LP, 2½" rectangular; Model 35-LP, 3" rectangular; and Model 45-P, 4½" rectangular.—*PACE Electrical Instruments Co., Inc., 70-31—84th St., Glendale 27, L. I., N. Y.*

For more information circle **194** on inquiry card.

SAFETY SWITCH

New Model SBS Safety Switch shuts down both pilot and main fuel flow by actuating a solenoid valve in the event of pilot flame failure. Under normal operating conditions, a mercury-filled bulb, installed close to the pilot flame, is heated to a bright red.



If, for any reason, the pilot flame is extinguished, the mercury vapor in the bulb condenses. This condensation interrupts the circuit to the solonoid valve or other devices. At the same time, an indicating needle will drop, showing that the pilot flame is out.—*Partlow Corp., 517 Campion Rd., New Hartford, N. Y.*

For more information circle **195** on inquiry card.

SMALL DIGITAL COMPUTER

New transistorized PCTC (Process Control Transistor Computer) for automatic control of industrial processes is now in the prototype stage. The first production models are expected to be available in 1960.—*Ferranti Electric Inc., Electronics Div., 95 Madison Ave., Hempstead, L. I., N. Y.*

For more information circle **196** on inquiry card.

INSTRUMENT DAVIS DIVISION

GAS ANALYSIS INSTRUMENTS

Continuous and Portable units

✓ **CHROMATOGRAPHIC ANALYZERS**

Complete systems for laboratory and process stream analysis — control.
CHROMA-CAT series extends utility of analysis, allows use of AIR as carrier gas.

✓ **ELECTRO-CONDUCTIVITY ANALYSIS**

Continuous measuring for PART PER MILLION toxic gases in work areas; impurity control in process streams. Applicable on any gases (or gas combustion products) which ionize in water.

✓ **COMBUSTIBLE GAS ANALYZERS**

REMOTE HEAD and multi-point systems for detection of combustible gases and vapors in work areas; Litho and coating oven atmosphere control; etc. Control of combustibles in inert gas streams.

✓ **THERMAL CONDUCTIVITY ANALYZERS**

MEASUREMENT of concentration of one gas component in a mixture of gases utilizing sensitive T/C filaments as the detector. Applicable for determination of: H_2 in $O_2 \cdot N_2$ mixtures; Argon in Air; Hydrogen purity; CO_2 in flue gas, etc.

Write for Descriptive Literature

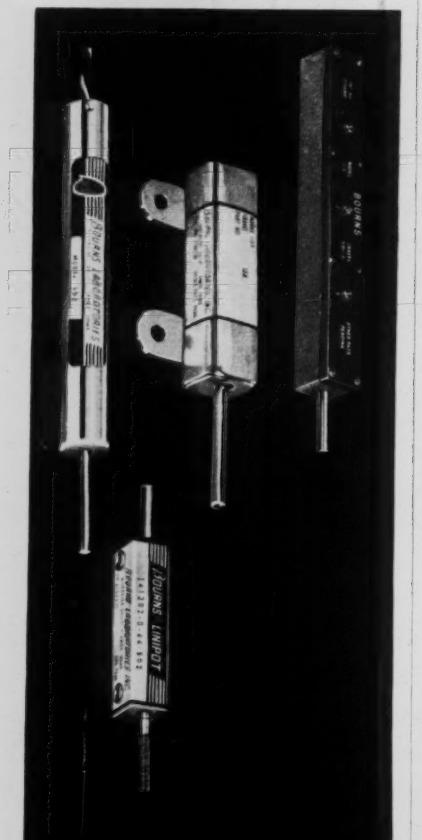
DAVIS INSTRUMENTS
A Division of Davis Emergency Equipment Co., Inc.
80 Halleck St., Newark 4, N. J.

For more information circle **86** on inquiry card.

POSITION TRANSDUCERS by BOURNS

The complete line of Bourns transducers is a result of over ten years engineering and manufacturing experience. Available in travels of ½" to 32", Bourns transducers are designed to give reliable service under extreme environmental conditions. Get time-proved dependability —specify Bourns in your instrumentation and test programs.

Write for new Instrument Brochure Number 3.



BOURNS
Laboratories, Inc.
P. O. Box 2112B, Riverside, Calif.
Field Engineering Offices:
L. I., New York, and Dallas, Texas

PIONEERS IN POTENTIOMETER TRANSDUCERS FOR POSITION, PRESSURE, AND ACCELERATION. EXCLUSIVE MANUFACTURERS OF TRIMPOT®, TRIMIT®

For more information circle **87** on inquiry card.

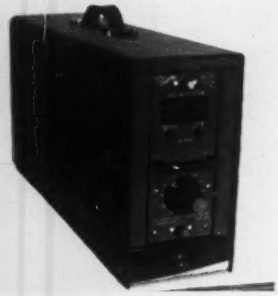
STANDARD RACK CABINET

New Model FT-192, a standardized Rack Cabinet, made of #11 gauge cold-rolled steel with #16 gauge end-bells, has hinged lift-out doors for full accessibility to internal components, and flush-type hardware. Units can be made also of aluminum and magnesium.—*Falstrom Co., 301 Falstrom Court, Passaic, N. J.*

For more information circle **197** on inquiry card.

CONTINUOUS-GAIN AMPLIFIER

New Model 512-A D-c Amplifier is chopper-stabilized and features eleven fixed-gain steps with continuously variable gain between each setting. Used for the amplification of signals from wire-strain-gage transducers; thermo-

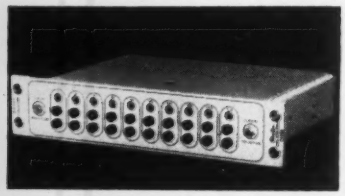


couples or other low-level, low- and medium-output impedance signal sources; its drift is ±2 uv max; noise is 12 uv rms (0-50 kc); frequency response is 0.3 db (from dc to 10 kc) to 3db (at 40 kc); linearity is better than 0.1%; and output is ±35 v (for resistance loads greater than 1000 ohms) to ±40 ma (for resistance loads of 4 to 400 ohms).—*Allegany Instrument Co., Inc., 1091 Wills Mountain, Cumberland, Md.*

For more information circle **198** on inquiry card.

REVERSIBLE BINARY COUNTER

New transistorized 10-stage Model 111B Indicating Reversible Binary Counter features both serial and parallel read-in and read-out. Eighteen vdc levels are available from either



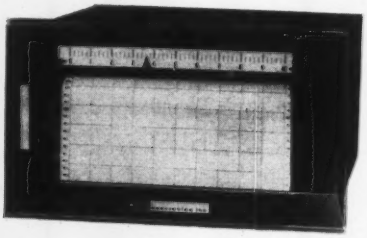
side of the counter stages. The units operate up to 200 kc with a single —20-v supply voltage. Both push-button and electrical presetting are available and any number of units may be cascaded.—*Navigation Computer Corp., 1621 Snyder Ave., Phila. 45, Pa.*

For more information circle **199** on inquiry card.

Where there's no margin for error...

westronics

RECORDING POTENTIOMETERS



11" CHART AVAILABLE WITH ONE or TWO PENS RECORDING FULL SCALE

FEATURING

SMALL SIZE

- Only 60% the size of old line instruments
- Designed for standard relay rack mounting

VERSATILITY

- Minimum span—1 MV
- Plug in range, MV or TC
- Chart drives, synchronous and/or selsyn, with large selection of speeds
- Marker pens, L and/or R
- Limit switches
- Transmitting slidewires

Also available: One and two pen 5" recorders

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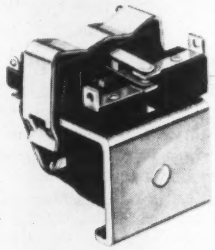
3605 McCART STREET • FORT WORTH, TEXAS

For more information circle **88** on inquiry card.

GENERAL PURPOSE RELAY

New Type FC DPST-Relay has silver contacts riveted to a molded panel. Rating is 2 amps resistive at



26.5 vdc or 115 vac. As a SPST-relay the Type FC can operate as low as 200 mw. As a DPST-relay it can operate up to 2 w.—*Allied Control Co., Inc., 2 East End Ave., New York 21, N. Y.*

For more information circle **200** on inquiry card.

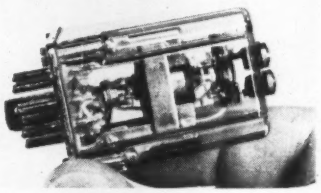
PROGRAMMING CONNECTORS

New line of miniature, quick-disconnect Programming Connectors with an insert arrangement of 14 #16 contacts for special computer applications is pre-wired and coded for particular circuitry. 3 standard receptacles are pressurized (30 psig) and incorporate a rubber "O" ring and seal. Connectors and receptacles have aluminum shells and diallyl phthalate dielectrics.—*Amphenol Connector Div. of Amphenol-Borg Electronics Corp., 1830 South 54th Ave., Chicago 50, Ill.*

For more information circle **201** on inquiry card.

NON-INDICATING METER RELAY

New Model 137 VHS Non-Indicating Meter-Relay has adjustable contacts permitting easy changing of



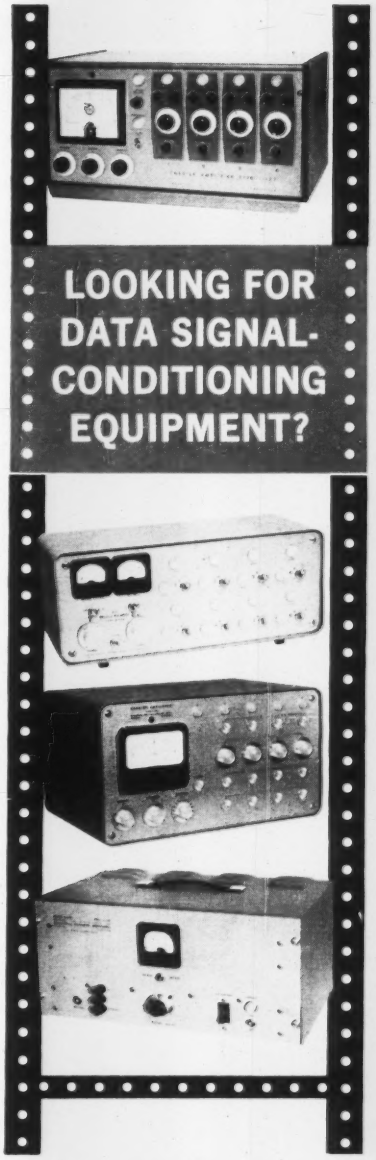
either control points or calibration. It will trigger control action on signal changes as small as 0.2-microamps or 0.1 mvdc. A rectifier is used for control from a-c signals.—*Assembly Products, Inc., Chesterland, Ohio.*

For more information circle **202** on inquiry card.

CORRECTION

Accuracy of the V/D-D/V Converter, Model TB-713 Transicon, which was described on page 434 of the March issue of I&CS was erroneously given as ±0.5%. The correct accuracy is ±0.05%. Manufacturer is: Epsco, Inc., 588 Commonwealth Ave., Boston 15, Mass.

For more information circle **160** on card.



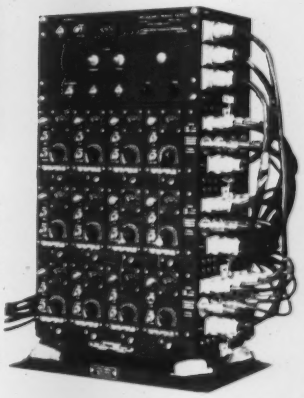
Type 1-127 Carrier Amplifier . . . Four channel 20-kc Carrier Amplifier will accept low level signals in the 0 to 5000-kc frequency range. Write for Bulletin 1550-X2.

These data amplifiers, bridge balances and power supplies are but a part of the most complete and fully integrated line of dynamic data processing equipment available anywhere.

Type 8-108 Bridge Balance . . . Provides coupling and a complete control center between as many as eight strain gages or resistive-bridge-type pickups and recording oscillographs. Four-channel type is also available. Write for Bulletins 1530-X2 and 1560-X25.

Type 1-118 Carrier Amplifier . . . Four-channel, 3-kc carrier amplifier provides frequency response from 0 to 600 cps. Unit features low cost and simplified operation. Write for Bulletin 1522-X13.

Type 3-132 Power Supply . . . Furnishes up to 1 ampere at 0 to 15 volts d-c with extremely high stabilization. Less than 1 millivolt drift in 24 hrs. Available for use with 50/60 or 400 cps power source. Three other power supply types also available. Write for Bulletin 1543-X13.



Amplifier System D . . . Multichannel, dual-purpose, amplifier system provides both linear-integrating and carrier amplifiers. Frequency response ranges from 5 to 5000 cps. Write for Bulletin 1403-X8.

Write for General Catalog 1310-X2 for a more complete description of these and other data processing instruments.

Electro Mechanical Instrument Division CEC

CONSOLIDATED ELECTRODYNAMICS/300 n. sierra madre villa, pasadena, california

FOR EMPLOYMENT OPPORTUNITIES WITH THIS PROGRESSIVE COMPANY, WRITE DIRECTOR OF PERSONNEL

For more information circle **89** on inquiry card.

RELIABILITY... THE SOLUTION TO YOUR ELECTRONIC COMPONENT PROBLEMS

Designing reliability into electronic components and instrumentation is Borg Equipment Division's business. Borg's reliable engineering, research and production facilities are at your service for commercial or military projects. Bring your component reliability problems to Borg. You'll enjoy working with our cooperative, creative engineering staff. The result will be a sound, practical and reliable solution at a considerable saving of time and money. Here are just a few of the products manufactured by Borg . . .

- FREQUENCY STANDARDS
- AIRCRAFT INSTRUMENTS
- POTENTIOMETERS
- MULTI-TURN COUNTING DIALS
- FRACTIONAL H. P. MOTORS
- SPECIAL DESIGNS

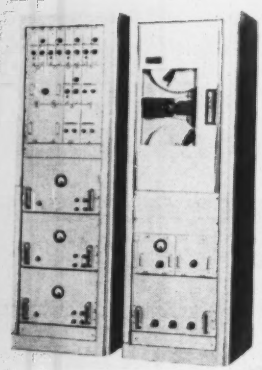
WRITE FOR COMPLETE ENGINEERING DATA

BORG Built by Borg

BORG EQUIPMENT DIVISION
AMPHENOL-BORG ELECTRONICS CORPORATION
JANESVILLE, WISCONSIN

For more information circle **90** on inquiry card.

WIDE-BAND MAGNETIC RECORDERS

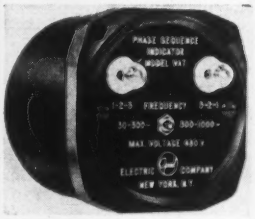


New Mincom CV-100 Series of precision Tape Recording Equipment comprises production units that can simultaneously record seven complete channels of video information, each of which requires one megacycle bandwidth. This can be done for a fifteen-minute period, on one reel of half-inch tape. Extremely careful attention has been afforded to phase response characteristics in the CV-100 hardware in order to reproduce to exacting specifications the transient phenomena so important in high-performance radar systems, aeronautical equipment, etc. —*Mincom Div. of Minnesota Mining & Mfg. Co.*, 2049 *So. Barrington Ave., Los Angles* 25, *Calif.*

For more information circle **203** on inquiry card.

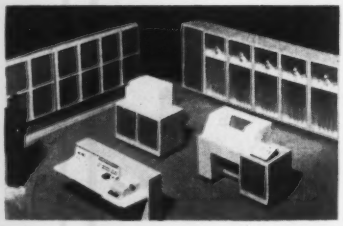
PHASE SEQUENCE INDICATOR

New panel-mounting Model VA7 Phase Sequence Indicator features an extended voltage and frequency range of from 104 to 480 v and 30 to 1000 cps. Sequence is displayed by means of two pilot lamps for both 1-2-3 and 3-2-1 sequence.—*Opad Electric Co.*, 69 *Murray St., New York* 7, *N. Y.*



For more information circle **204** on inquiry card.

BUSINESS COMPUTER

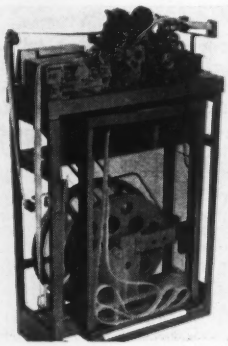


New Model 800 medium-scale business computer shows considerable compactness achieved through all-transistor design. Its prime feature, automatic parallel processing, allows it to do up to eight jobs simultaneously, providing the user with great scheduling flexibility. Expandable by addition of modules.—*DATA-matic Div., Minneapolis-Honeywell, Newton Heights* 61, *Mass.*

For more information circle **205** on inquiry card.

AUTOMATIC MESSAGE RELAY

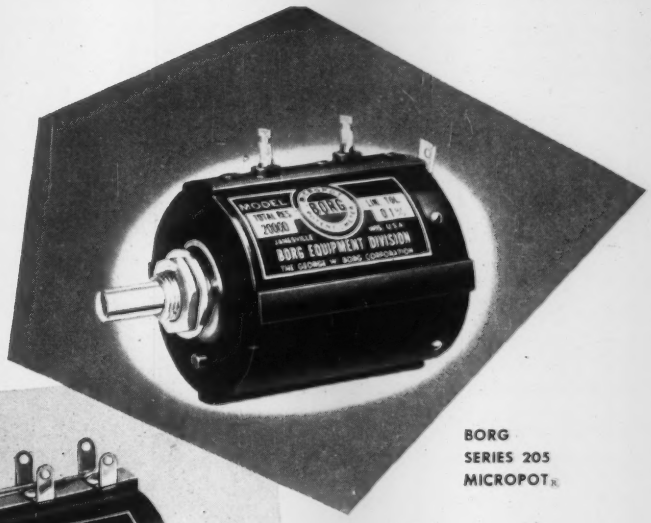
New Automatic Message Relay, Model 28 RT, (reperforator transmitter-distributor), is a high-capacity self-contained punched-tape message relaying facility for receiving wire signals at speeds ranging from 60 to 200 words/min, converting them into perforations in paper tape, and transmitting them at the same or another speed to local or remote receiving stations. Set consists of (1) a receiving unit, (2) a sending unit, and (3) a tape handling unit. Receiving and sending units will operate at the same or different speeds, e.g., receive at 60 wpm, transmit at 100 wpm.—*Teletype Corp.*, 4100 *Fullerton, Chicago* 39, *Ill.*



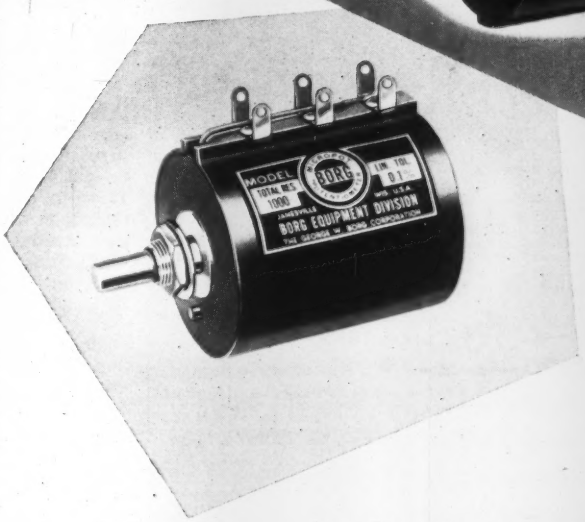
For more information circle **206** on inquiry card.

TREAT 'EM ROUGH..

MICROPOTS CAN TAKE IT!



BORG
SERIES 205
MICROPOT®



BORG
SERIES 1100
MICROPOT®

We're rough on Borg Micropots, too — when it comes to testing for reliability. Take Series 205 and 1100 Micropots for example . . .

	Mechanical Rotation	Electrical Rotation	Linearity Accuracy	Torque Starting	Torque Running	Life Expectancy
Series 205	3600°+15°−0°	3600°+14.4°−0°	±0.1% to ±0.05%	−3.0" oz.	−1.5" oz.	1,000,000 revolutions plus
Series 1100	3600°+30°−0°	3600°+15°−0°	±0.5% to ±0.1%	−3.0" oz.	−1.5" oz.	500,000 revolutions plus

Testing of this type tells us how life and reliability are affected . . . the environmental limitations for each model . . . which series to recommend for your specific job!

You may be using high-priced pots unnecessarily in your present project. You may be able to reduce the number of components in your circuits. Remember . . . the fewer the components, the greater the reliability!

Let us send you the name of your nearest Borg "Tech-Rep" and a complete rundown on all Borg Micropots today.

Write for CATALOG BED-A90

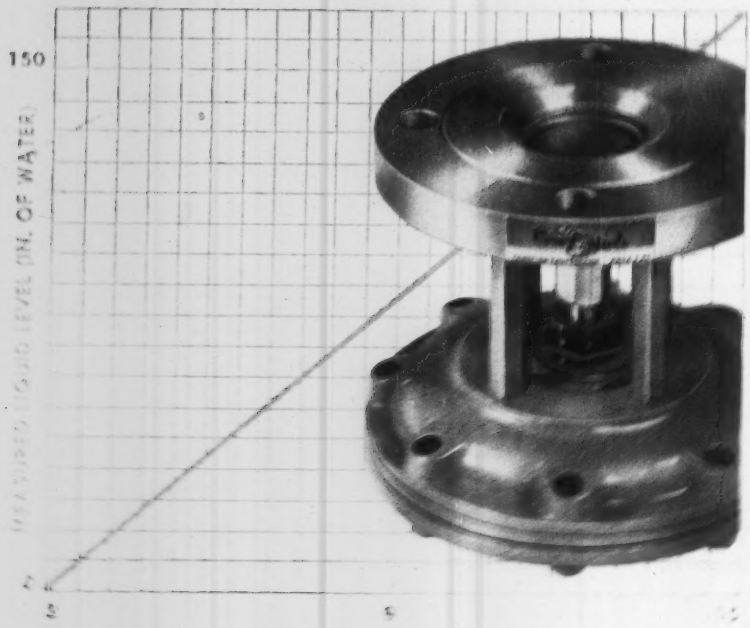
BORG®

MICROPOTS
MICRODIALS
MOTORS

BORG EQUIPMENT DIVISION
AMPHENOL-BORG ELECTRONICS CORPORATION
JANESVILLE, WISCONSIN

For more information circle 91 on inquiry card.

TYPICAL PERFORMANCE CURVE OF MODEL "P" TRANSMITTER



TRANSMITTED AIR SIGNAL (PSI)

NEW

CONOFLOW

LIQUID LEVEL & PRESSURE TRANSMITTER

WITH

Extraction

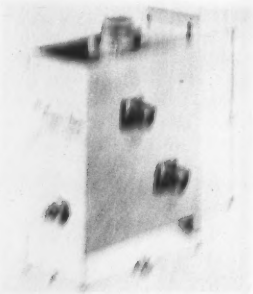
ISOLATED MEASURING DIAPHRAGM

[redacted]

CONOFLOW CORPORATION

D-P TRANSMITTER

[redacted]



Goat Rescues Engineers!

The GOAT (*Gerber Oscillogram Amplitude Tabulator*) is an entirely new instrument. It reads amplitudes conventionally or peak-to-peak, subdivides timing lines, and PRINTS both amplitude and time reference in tabular form. Zero location instantly reset to any reference line. Resolution—.001 inch or .1 mm. This complete data reduction system, including printer, only $995.

Gerber features a complete line of data reduction instruments, systems and scanners. Write or call—

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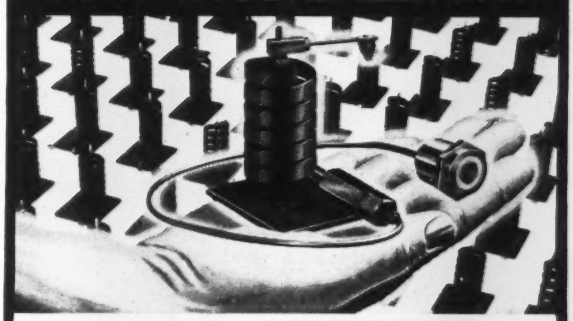
For more information circle **93** on inquiry card.

I.I.C. PRESSURE ELEMENT



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0-15 P.S.I. to 0-10,000 P.S.I.

I.I.C. offers you a new dimension of accuracy, dependability and long life in a new Pressure Element. This Element's linearity and repeatability are constant assuring accurate recording.

Low maintenance and rugged construction in addition to the versatile quality of I.I.C.'s Pressure Element make it the very finest pressure element manufactured.

We Invite O. E. M. Accounts
Manufactured to Your Specification

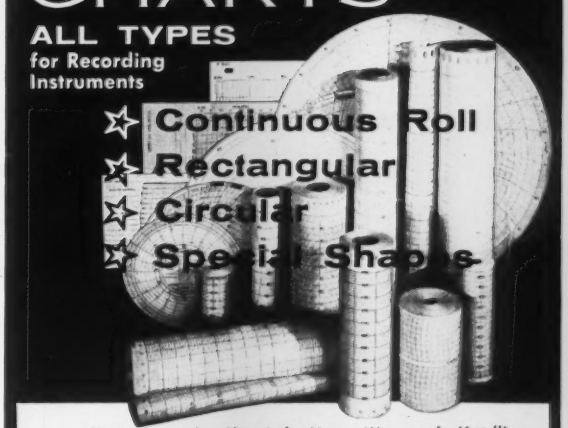
INDUSTRIAL INSTRUMENT CORP.

8400 RESEARCH ROAD — AUSTIN TEXAS

For more information circle **94** on inquiry card.

GUBELMAN CHARTS

ALL TYPES
for Recording Instruments



- Continuous Roll
- Rectangular
- Circular
- Special Shapes

Charts for Ink, Electrical, Heat, Wax and Metallic Stylus-Recording.

Special time numbering, perforations, and graphic design cycles available to meet unusual requirements.

All Charts are produced under automatically controlled atmospheric humidity conditions.

Our complete chart manufacturing facilities and wide experience have served and progressed with the instrument industry since 1908.

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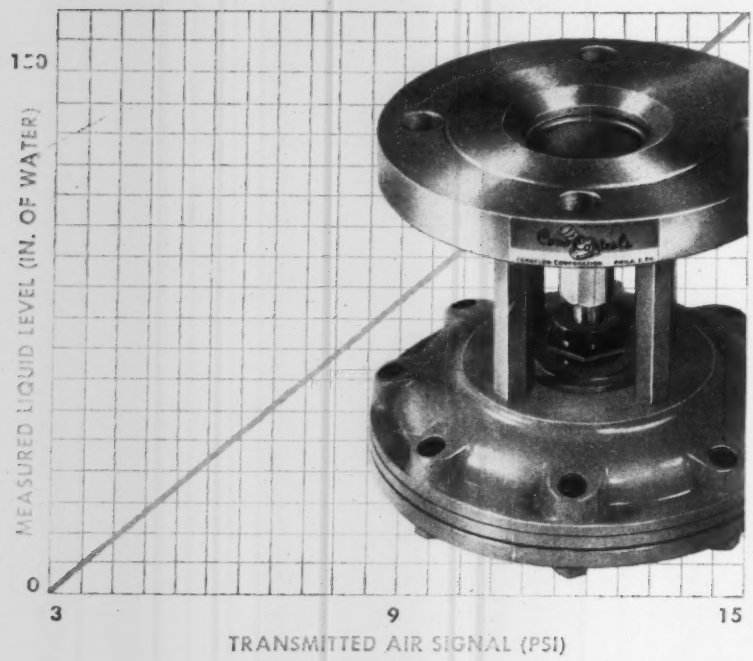
INCORPORATED
(FORMERLY NAMED GUBELMAN PUBLISHING CO.)
100-106 EAST KINNEY STREET, NEWARK 5, N. J.

TYPICAL PERFORMANCE CURVE OF MODEL "P" TRANSMITTER



NEW

CONOFLOW

LIQUID LEVEL & PRESSURE

TRANSMITTER

WITH

Exclusive

ISOLATED MEASURING DIAPHRAGM

The Conoflow Model "P" Transmitter is a rugged instrument which measures pressure and liquid level and transmits a *linear* 3-15 psi signal to standard receiver elements. Incorporates these cost-saving features:

Safety—Process liquids and gases cannot back up through air lines and damage costly instruments. This is guaranteed by the complete separation of measuring diaphragm from pneumatic pilot.

Simple Installation—The Model "P" can be mounted either horizontally or vertically on open or closed vessels. No dip tubes, floats or other mechanical devices are required inside the tank.

Long Life—Only the corrosion-resistant *Inconel X* diaphragm is exposed to the measured material. Preformed diaphragm will not work-harden or fatigue; withstands pressures to 500 psi and temperatures to 450°.

Versatile—Can be used for practically any service; ideal for viscous fluids or materials with solids in suspension; also for flowing bulk materials such as pigments, flakes, etc.

Choice of Ranges—Available for measuring ranges as low as 0 to 100" of water and pressures as high as 250 psi. Ranges can be changed in the field.

Specifications—Bulletin IA-2520-3 contains complete specifications on the Conoflow Model "P" Transmitter. Write for your copy today or let us quote on your requirements. No obligation. Conoflow Corporation, 2100 Arch Street, Philadelphia 3, Pa.

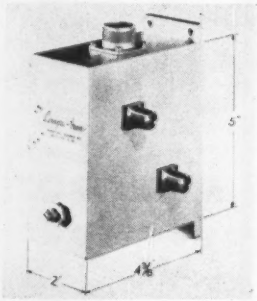
CC-802

Conotrols® **CONOFLOW CORPORATION** *FOREMOST IN FINAL CONTROL ELEMENTS* SUBSIDIARY OF WALWORTH

For more information circle **92** on inquiry card.

D-P TRANSMITTER

New Compu-tran shock-resistant Differential-Pressure Transmitter, Model 70-2900, features 0.2% measurement accuracy, infinite resolution, and zero output pre-set at any point

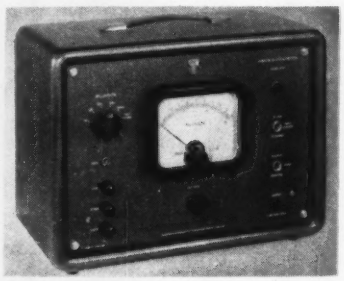


throughout the range. Suitable for corrosive atmospheres it is available in static-pressure ranges from 0-100 to 0-3000 psig with differentals up to 100% of range. Inputs available are 6.3 vdc or 110 vac, and full-scale outputs available are 50 mvdc or 5v ac or dc. Sensing element of the unit is a differential transformer with a built-in demodulator for d-c outputs. Differential sensitivity is one part in 1000 or better.—*International Resistance Co., Computer Components Div., 401 North Broad St., Phila. 8, Pa.*

For more information circle **207** on inquiry card.

ELECTROMETER

New imported Vibron Electrometer, Model 33B, is vibrating-condenser general-purpose d-c amplifier for measuring of small d-c voltages and



currents derived from a high-resistance source. It neither generates nor absorbs any current from the component under test, and hence can be used for measurements which are far beyond the capabilities of the conventional d-c amplifier. It detects currents as small as 10^{-15} amps and measures resistances as high as 10^{15} ohms. Input ranges are 10, 30, 100, 300 and 1000 mv. Accuracy is ±0.3% in the 1000-mv range, and ±2% in the 10-mv range. The d-c output is 1 mamp full scale deflection in all ranges.—Bulletin 1033 contains details.—*Herman H. Sticht Co., Inc., 27 Park Pl., New York 7, N. Y.*

For more information circle **208** on inquiry card.

Goat Rescues Engineers!

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Gerber features a complete line of data reduction instruments, systems and scanners. Write or call—

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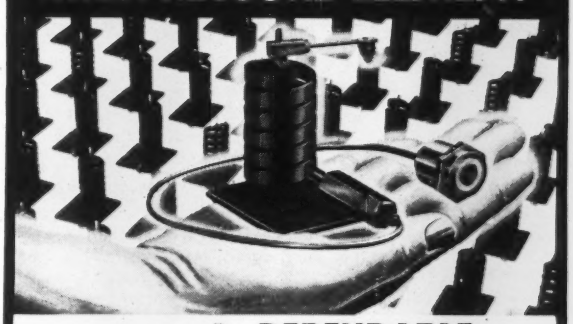
I.I.C. PRESSURE ELEMENT



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I.I.C. offers you a new dimension of accuracy, dependability and long life in a new Pressure Element. This Element's linearity and repeatability are constant assuring accurate recording.

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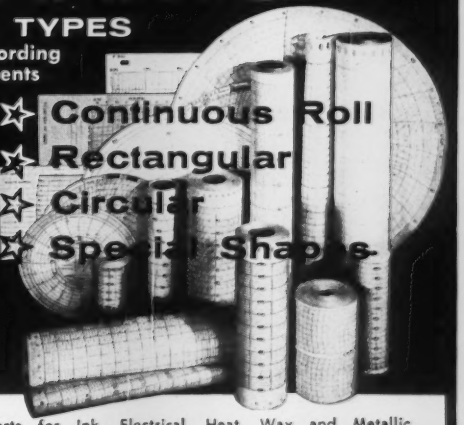
For more information circle **94** on inquiry card.

GUBELMAN CHARTS

ALL TYPES
for Recording Instruments

- Continuous Roll
- Rectangular
- Circular
- Special Shapes



Charts for Ink, Electrical, Heat, Wax and Metallic Stylus-Recording.

Special time numbering, perforations, and graphic design cycles available to meet unusual requirements.

All Charts are produced under automatically controlled atmospheric humidity conditions.

Our complete chart manufacturing facilities and wide experience have served and progressed with the instrument industry since 1908.

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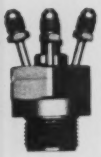
PHOTOCON TRANSDUCERS

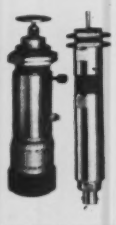
– for measuring combustion, fuel, and oxidizer pressures... high-level noise, displacements, and thrust.

- wide frequency response–from 0 to 15,000 cps.
- for severe environmental conditions.
- cable lengths up to 1800 feet.

PHOTOCON
PRESSURE TRANSDUCERS
–ranges from 5 psig to 100,000 psig. Diaphragm temperature: To 6000°F with water cooled models.



PHOTOCON
PROXIMITY AND DISPLACEMENT TRANSDUCERS
–measure displacement from .000001 to 2".



PHOTOCON
MICROPHONE TRANSDUCERS
–for sound pressures from 80 db to 220 db, and higher.

DYNAGAGE–electronic readout systems for all Photocon transducers – accurately measure static and dynamic pressures and displacements. Compact... lightweight... simplified operation...wide frequency response ...easy to install.

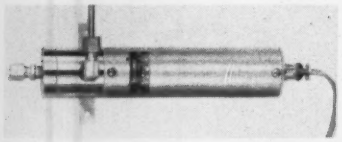
PHOTOCON RESEARCH PRODUCTS
421 NORTH ALTADENA DRIVE, PASADENA, CALIF.

Pressure, Microphone,
Proximity & Displacement Transducers
Dynagage Readout Instruments.

For more information circle **95** on inquiry card.

SMALL-FLOW METERS

New Mark X Flow Rate Transducer senses flows as low as 0.002 gpm and translates them (at high static pressure and temperature) into a linear



electrical signal. The miniature variable-area type flow sensor has a specially-shaped body of fixed size moving in a tapered tube, with the core of a differential transformer attached to the body. All parts exposed to fluid medium are of stainless steel. Accuracy is 1% of flow rate when calibrated with operating fluid. Voltage output is linear relative to fluid flow rate within 0.5% over rated range. Output voltage is 0-100 mv.—*Ramapo Instrument Co., Inc., Bloomingdale, N. J.*

For more information circle **209** on inquiry card.

MOISTURE REGISTER

New Model PM Moisture Indicator for use on moving paper rolls has electrodes consisting of two hardened metal rollers, ball-bearing mounted, for operation on moving material or

for stationary rolls, stacks, and skids. Measurement is by radio-frequency determination of the dielectric constant of the sample. A nomograph can be used in place of calibration curves when testing pure papers. The nomograph converts dial readings into moisture content by using the density of the paper for correction of different types of paper. The nomograph holds true as long as the basic weight of the paper does not vary.—*Moisture Register Co., Alhambra, Calif.*

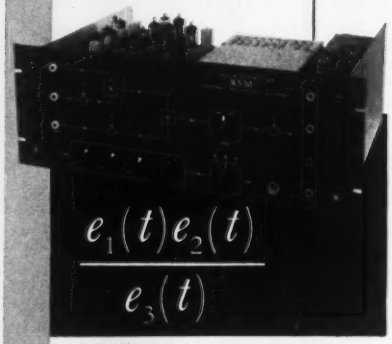
For more information circle **210** on inquiry card.

DATA LOGGING SYSTEM

New Automatically Programmed Remote Indication Logging system ("April") converts analog-type quantities to a binary-code form and transmits the information from a remote location, by means similar to that used in the Company's standard supervisory equipment.—*General Electric Co., Schenectady 5, N. Y.*

For more information circle **211** on inquiry card.

The plus is precision!



NEW analog multiplier-divider by Philbrick

This is Philbrick's K5-M — which provides improved long term stability. Accuracy, including drift, is better than 0.10v in all 4 quadrants.

FEATURES:

- Accepts 3 variable inputs e_1, e_2, e_3 and yields $e_1 e_2 / e_3$
- 3-digit decade provides adjustable scaling voltage
- Useful response even beyond 10 kcps.
- Needs no auxiliary equipment to obtain products, ratios, squares, square roots, etc.
- Requirements: 115vac filament power; 110ma at ± 300vdc
- Mounts on standard 7" rack panel

Here's a new and higher degree of *precision*, *speed*, and *flexibility* at your fingertips for analog computation, correlation, precision modulation, control, many other applications.

For full informaton, write:
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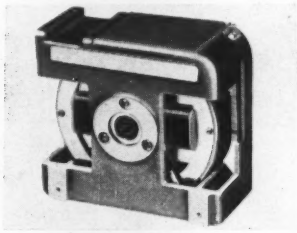
285 Columbus Ave., Boston 16, Mass.
COmmonwealth 6-5375

THE ANALOG WAY IS THE MODEL WAY

For more information circle **96** on inquiry card.

A/D ENCODERS

New Series 2100 ElectroSyn Encoders convert rotary motion to a coded electrical output, suitable for long-distance transmission and log-

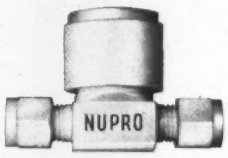


ging of temperature and pressure readings. Designed primarily for use with Series 800 ElectroSyn indicating Receiver they are available with digital ranges of 0-999 or 0-1999. Ambiguous or between-point readings are eliminated by means of an electromagnetic antiambiguizing mechanism. Metal-clad plastic discs for the Norwood encoders can be designed for any type of code including the standard teletype code.—*Norwood Controls, Div. of American Standard Products, Norwood, Mass.*

For more information circle **212** on inquiry card.

HIGH-VACUUM VALVES

New Nupro Plastic High-Vacuum Valves incorporating a non-rotating stem, specifically designed for high



vacuum, can be used in process control lines, instrument air lines, corrosive conditions, etc., and are available in polyethylene Zytel (nylon), Teflon, Plaskon and other plastics, with Swagelok and pipe-thread ends. —*Nuclear Products Co.*, 884 *E.* 140*th St., Cleveland* 10, *Ohio.*

For more information circle **213** on inquiry card.

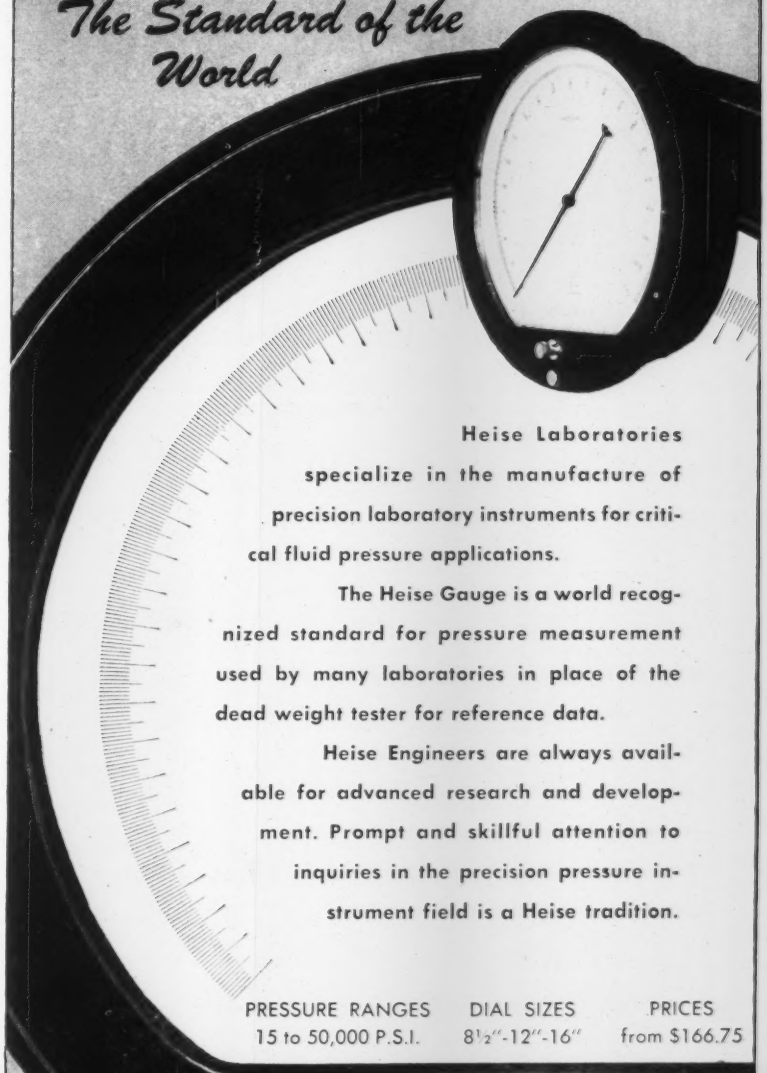
TEFLON INSTRUMENT TUBING

New Teflon Tubing meets all military, SAE and ASTM specifications for use in fluid streams, laboratory constructions, instrumentations, metric tubing and tubing connectors. Fittings are available to secure the tubing to medical syringes and needles. The tubing can be sterilized easily and is translucent for viewing streams. Sizes range from 0.010" to 1" and larger. Millimeter sizes are available from stock.—*Pennsylvania Fluorocarbon Co., Inc.*, 1115 *North* 38*th St., Phila.* 4, *Pa.*

For more information circle **214** on inquiry card.

HEISE GAUGES

The Standard of the World



Heise Laboratories specialize in the manufacture of precision laboratory instruments for critical fluid pressure applications.

The Heise Gauge is a world recognized standard for pressure measurement used by many laboratories in place of the dead weight tester for reference data.

Heise Engineers are always available for advanced research and development. Prompt and skillful attention to inquiries in the precision pressure instrument field is a Heise tradition.

PRESSURE RANGES	DIAL SIZES	PRICES
15 to 50,000 P.S.I.	8½"-12"-16"	from $166.75

DELIVERY within 30 days

HEISE BOURDON TUBE COMPANY, INC.
BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

For more information circle **97** on inquiry card.

TRY THIS FRESH APPROACH

to the measurement of displacement

IRC

DISPLACEMENT TRANSDUCERS

No longer are weak outputs a problem in the application of displacement transducers to the measurement or indication of mechanical movements electrically.

You have a reliable source for displacement transducers—International Resistance Company—offering you a vastly superior precision product *at a lower cost.*

Better Linearity—as low as 0.1%
Better Sensitivity—2.0 MV/Volt Input/Mil at 60 cycles
Linear Range: .005" to 4.0"
Frequency: 50 to 20,000 CPS
Null Voltage: 0.25% of total output, or less
No moving parts to wear
Longer, Infinite Life
Resolution: Infinite
Precision assured by close control at every step in manufacture

Special designs available for:
- **High temperature (1200 F)**
- **Nuclear radiation resistance**
- **120V. inputs; up to 50V. outputs**
- **Zero temperature coefficient**
- **Matched units for complete interchangeability**

For complete information including many more advantages of IRC Displacement Transducers write for Bulletin R-3b.

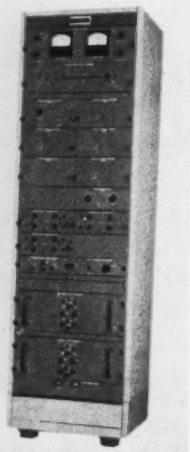
Compu-tran

International Resistance Company
COMPUTER COMPONENTS DIVISION
Dept. 452, 401 N. Broad St., Philadelphia 8, Pa.
In Canada: International Resistance Co., Ltd. Toronto, Licensee.

For more information circle **98** on inquiry card.

A/D COMPUTER LINKAGE SYSTEMS

New family of analog/digital Computer Linkage Systems, employing a number of information channels to convert analog outputs (process variables) into digital form and digital

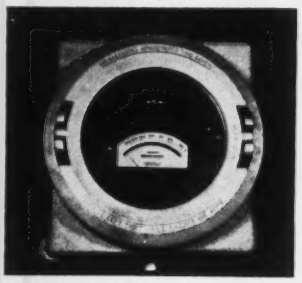


computer outputs (controller commands) into analog form, uses extensively solid-state circuitry on etched-circuit cards. Model 4.030 System, shown, links an IBM 700-Series EDPM and an EAI analog computer by providing 20 analog-to-digital and 10 digital-to-analog information channels.—*Electronic Associates, Inc., Long Branch, N. J.*

For more information circle **215** on inquiry card.

MASS FLOW INDICATOR

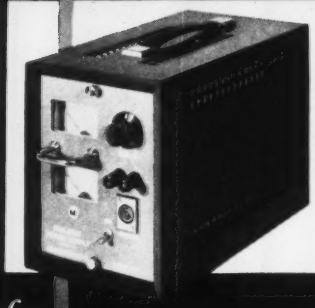
New electrical Gas Flowmeter, calibrated for true mass flow, is UL approved for Class 1, Group D hazardous areas. Consisting of a Model FI-6 Gas Flow Indicator and a Type S-16-B Gas Flow Probe, it has the unique feature that the voltage is limited to a fraction of a volt and the current to a small fraction of an amp. No corrections for temperature or pressure



are necessary. The indicator is furnished with a linear scale from 0 to 200. Calibration curves are available for air over the range from 25-6,000 ft/min at S.T.P. or from 2-450 lb/min/sq ft of cross sectional area.—*Hastings-Raydist, Inc., Hampton, Virginia.*

For more information circle **216** on inquiry card.

Absolute ISOLATED DC POWER SOURCE



for
- **RESISTANCE-TYPE TRANSDUCERS**
- **STRAIN GAGES**
- **ACCELEROMETERS**

Now for the first time you can have the dependability and ease of operation of an electronic power supply *plus* the isolation normally obtained only from a battery. The Moeller Model 21 Power Supply exclusively provides *absolute isolation from line voltage and line ground.*

The Model 21 provides 0-20 volts, 1 amp of power for strain gages and resistance-type transducers. This transistorized instrument gives improved performance with existing single-ended and differential amplifiers and offers voltage regulation, internal impedance, ripple and stability equal to, or superior to, conventional transducer power supplies.

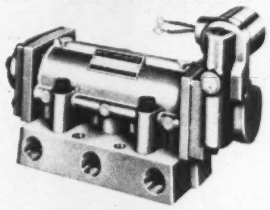
Write for descriptive literature.

M **MOELLER INSTRUMENT CO.**
ELECTRONICS DIVISION
132nd Street & 89th Avenue
Richmond Hill 18, N. Y.

For more information circle **99** on inquiry card.

SOLENOID CONTROL VALVES

New Type B ½" poppet-pilot single and double solenoid-operated Control Valves, with full ½" flow (257 cfm at 100 psig), have housings of aluminum castings and straight-through bore. Flow is through the hollow radially-ported stainless-steel plunger and out the connected piping. Valves are

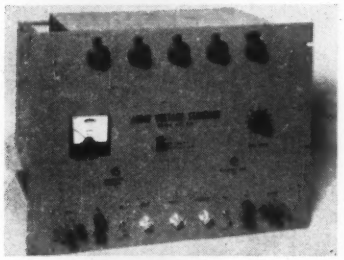


available in 2-way, 3-way or 4-way actions; two-position and three-position designs.—4-page Bulletin 582A gives details.—*Hunt Valve Co., Salem, Ohio.*

For more information circle **217** on inquiry card.

VOLTAGE CALIBRATOR

New A-C Voltage Calibrator, Model AVS-321, provides absolute voltages accurate to 0.1% by setting the digital controls. Accuracy is maintained at all frequencies from 35 cps to 10 kc.

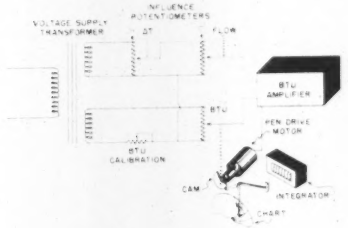


Output wave form is sinusoidal with less than 0.15% distortion.—*Holt Instrument Labs., Oconto, Wis.*

For more information circle **218** on inquiry card.

BTU METER

New Model 913 Btu Meter for heat transfer in hot-water generators, cooling towers, refrigerating systems, and



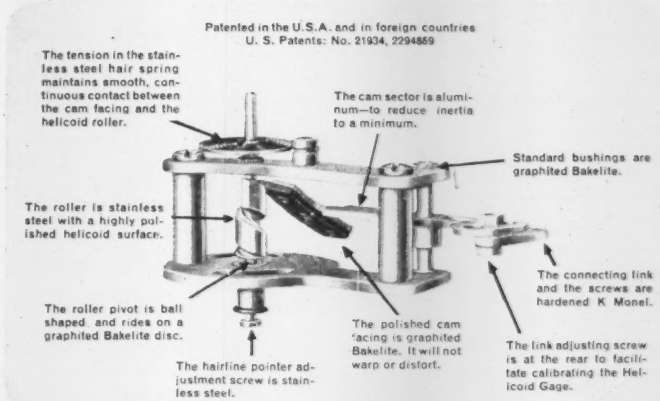
other such heat exchangers in power and process industries, records temperature differential and flow rate on the same chart also. Unit works on resistance-bridge principle.—*Hays Corp., Michigan City, Ind.*

For more information circle **219** on inquiry card.

ACCO Helicoid Gage U.S.A.

Nothing but the best in gages for working pressures from 30" vacuum to 10,000 p.s.i.

These details of Helicoid gage design assure longer life and enduring accuracy


Patented in the U.S.A. and in foreign countries
U. S. Patents: No. 21934, 2294859
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is aluminum—to reduce inertia to a minimum.
Standard bushings are graphited Bakelite.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

The superiority of Helicoid Gages is most evident in severe service—wherever a gage is subjected to violent pressure pulsations or severe mechanical vibrations.

The *sustained accuracy* of Helicoid Gages over *millions of cycles* is explained by the details of design and construction of the Helicoid movement shown above. Such Helicoid features—protect against wear and corrosion and assure sensitivity, sustained accuracy and trouble-free operation.

The Chemical Gage

The Helicoid Chemical Gage has a guaranteed accuracy of plus or minus 1%. It is applicable for working pressures from 30" vacuum to 5000 p.s.i. and temperatures to 400° F. It is particularly suitable for chemicals and other viscous fluids which might clog or corrode a Bourdon tube. Pressure and/or vacuum is transmitted directly to the indicating gage element through deflection of a Teflon or Kel F sealing diaphragm.

Tubes built for millions of pressure pulsations

To fit the wide range of applications, Helicoid Bourdon tubes are available in four materials—alloy steel, K Monel, stainless steel and phosphor bronze.

All Helicoid tubes are made from seamless tubing and are carefully designed to give maximum torque and minimum stress. When used within the dial range, they will withstand many millions of pressure pulsations and will not stretch, leak or crack.

For complete information on the Helicoid line of gages write for **Catalog G-52**

Helicoid gives you all these features at prices that are competitive in the quality gage field.

Helicoid Gage Division
AMERICAN CHAIN & CABLE

929-B Connecticut Avenue • Bridgeport 2, Connecticut

ACCO TRADE MARK

For more information circle **100** on inquiry card.

A Logical Deduction

Because the design of an NJE SOLID STATE transistorized power supply permits **no compromise with quality;**

Because every transformer and choke is a **MIL-T-27-A** style unit; every resistor is **wire-wound;** every capacitor is the **finest** of its type;

Because **every** component is significantly derated at the **worst combination** of line, load, and ambient conditions, including repeated short circuits and critical partial overloads;

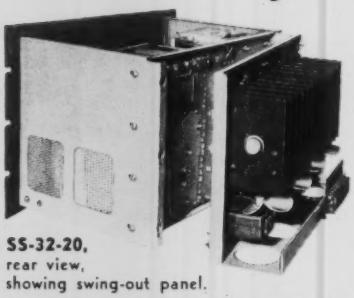
Because NJE "regulation" is the **total** of the **worst simultaneous combination** of line and load effects, static and dynamic;

Because NJE circuitry provides **stability,** against both time and temperature, **better than the rated regulation;**

Because we build all 14 standard models from three mass-produced "building blocks", **very competitively,** despite higher quality,

It follows that your best buy in a transistorized power supply is NJE SOLID STATE.

QED... choose NJE



SS-32-20,
rear view,
showing swing-out panel.

MODEL	VOLTS	AMP.	MODEL	VOLTS	AMP.
SS-7-15	0-7	0-15	TR-36-1	0-36	0-1
SS-10-10	0-10	0-10	SS-1603	0-160	0-1.5
SS-10-50	0-10	0-50	SS-1605	0-160	0-3.0
TR-18-2	0-18	0-2	SS-3600	10-36	0-50
SS-32-3	0-32	0-3	SS-1503	100-150	0-1.5
SS-32-10	0-32	0-10	SS-3003	200-300	0-1.5
SS-32-20	0-32	0-20	SS-1505	100-150	0-3.0

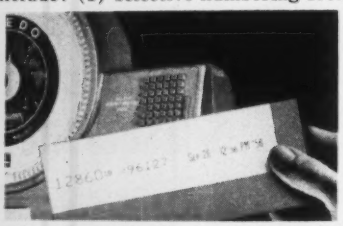
NJE CORPORATION

345 Carnegie Avenue, Kenilworth, New Jersey
CH 1-1500 TWX - Roselle, N. J. 51 FAX - FFP

For more information circle **101** on inquiry card.

WEIGHT PRINTER

New Printweigh "400" Scale prints a complete weight figure, even when unit weights are used to increase dial capacity. Available optional features include: (1) selective numbering from

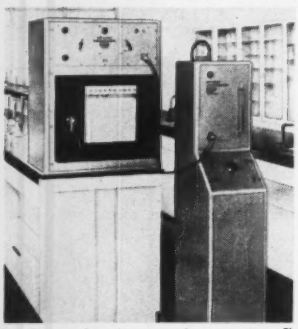


keyboard on the front of the Printweigh; (2) weight identifying symbols actuated by keyboard; (3) automatic consecutive numbering, (4) automatic time and date mechanism. (5) others which allow transmission of digital weight data to remotely located adding- or other office-machines, and (6) "memory" to store data.—*Toledo Scale, Div. of Toledo Scale Corp., 1079 Telegraph Rd., Toledo 12, Ohio.*

For more information circle **220** on inquiry card.

GAS-LIQUID CHROMATOGRAPH

New British-made Pye Argon Chromatograph employs an ionization detector system which enables it to detect as little as 2×10^{-11} moles of most organic substances; it maintains stability and reproducibility virtually independent of temperature, pressure, or flow rate. Degree of control is set



solely by column requirements. Samples as small as 0.025 microliter can be handled.—*Jarrell-Ash Co., 26 Farwell St., Newtonville 60, Mass.*

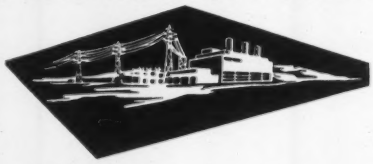
For more information circle **221** on inquiry card.

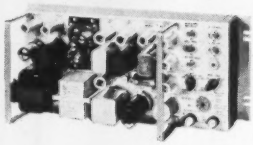
STABILIZED POTENTIOMETER VOLTAGE

New continuous Voltage Stabilizer, incorporated in circular and strip-chart electronic potentiometers, accurately regulates the d-c reference voltage supply to the measuring circuit by Zener diodes, making standardization by batteries or standard cells unnecessary.—*Brown Instruments Div., Minneapolis-Honeywell Regulator Co., Wayne and Windrim Aves., Phila. 44, Pa.*

For more information circle **222** on inquiry card.

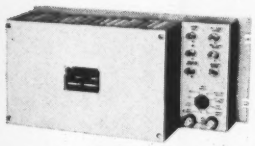
Telemeter ANY VARIABLE from Remote Points





MODEL 1025 Transmitter

MODEL 1090 Receiver



Accurate, Fast Acting, Frequency Type Telemeter for Transmission over Wire Lines, Microwave, and Power Line Carrier

Accurate HIGH-SPEED Continuous Telemeter for VOLTS AMPS WATTS VARS ETC.

•

Built-in Self-Calibrating Circuit

•

The Model 1025 Telemeter Transmitter converts DC mv from thermal converters, etc., to 10-30 cps which frequency modulates a built-in audio tone channel. AC 10 to 30 cps or relay outputs are also available. Receiver detects and demodulates transmitted signal, generating a DC mv for operation of recorders or indicating instruments. Up to 45 telemeters can be multiplexed.

Any communication link, including power line carrier, microwave or wire line may be used.

Over-all accuracy is 1% with a response speed of 1 second. Equipment features a built-in calibration circuit for 10% and 90% receiver check, and 10 cps and 30 cps transmitter check.

Any quantity which may be converted into a DC millivoltage or will operate a slidewire may be telemetered.

WE CAN HELP YOU
Our Applications Department is ready to assist you in your control, telemetering or communications problem. Phone DEerfield 4-3100.

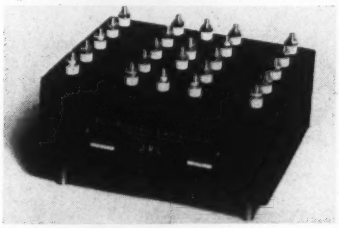
Write for Technical and Application Data.

Radio Frequency LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

For more information circle **102** on inquiry card.

DECADE RESISTANCE SETS

New line of ultra-precise ultra-stable Resistance Sets is assembled in decade form. Three models are available to cover the ranges from below 100 ohms to over 1 megohm: The DRM-104, composed of twelve 1000-ohm resistors, with a 10-ma current rating; the DRM-105, composed of twelve 10,000-ohm resistors rated at 2 ma; and the DRM-106, which utilizes twelve 100,000-ohm resistors rated at 1 ma. Each set consists of twelve

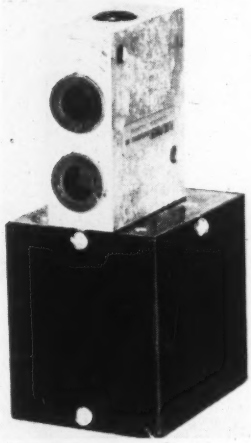


identical resistors of primary-standard accuracy. By selective interconnection, resistance values over a 144-to-1 range (from 12 connected in shunt to 12 connected in series) can be obtained to 0.0015% accuracy. Ratio standards (including decade ratios) can be synthesized over a 36-to-1 range, and the set can be used as the 11 resistance stages required in a Kelvin-Varley "decade."—*Julie Research Labs. Inc.*, 556 *West* 168*th St., New York* 32, *N. Y.*

For more information circle **223** on inquiry card.

H-P SOLENOID VALVES

New line of Solenoid Valves for pressures up to 3000 psig is made in 2-way poppet construction (which assures leak-tight sealing when closed) and 3-way construction, operated by



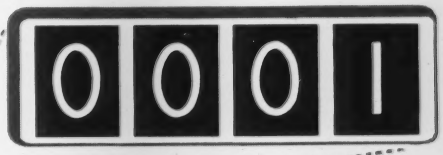
direct spool. 2-way valves are available in ¼", ⅜" and ¾" NPT for a-c or d-c voltage; 3-way valves in ⅜" NPT size for a-c voltage have maximum working pressure 2000 psig. —2-page bulletin and outline drawings give details.—*Fluid Power Accessories, Inc.*, 2051 *Railroad Ave., Glenview, Ill.*

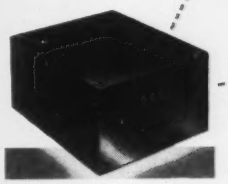
For more information circle **224** on inquiry card.

The **NEW** *Series* **BH100**

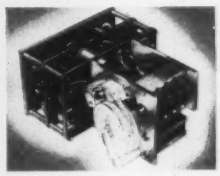
MILLI-V-METER*

DIGITAL READOUT

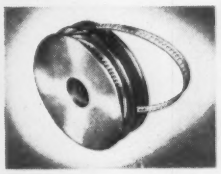




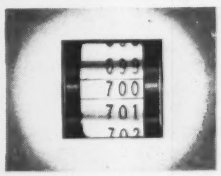
SMALL SIZE *— This compact, transistorized, servo-driven instrument measures only 3 x 5 x 5¾".*



ALL INCLUSIVE *— With Zener reference, power supply, amplifier, servo motor, 144" tape-slidewire.*



TAPE-SLIDEWIRE *— Mounted on side-by-side spools, slidewire is embedded in edge of tape, punched for sprocket drive.*



PRINTED READOUT *—Calibration printed on tape available to measure steady-state conditions or where input deviates more than 13%.*

ACCURACY 0.1%

THE INSTRUMENT with the TAPE-SLIDEWIRE

for

FLOW · PRESSURE

LEVEL · TEMPERATURE

etc.

- Every scale division is a calibrated point.
- 100 calibrated points per foot of slidewire length.
- Slidewires up to 12 feet long.

LINEAR, PARABOLIC, LOGARITHMIC FUNCTIONS ARE DISPLAYED IN DIRECT DIGITAL RELATION

* TRADE MARK

Full information is available for the asking!

B & H INSTRUMENT CO., INC.

3479 West Vickery Blvd. • Fort Worth 7, Texas

Sales-Engineering Offices: COMPTON, CAL., VALLEY STREAM, L.I., N.Y., DAYTON, OHIO

For more information circle **103** on inquiry card.

KNOW YOUR SPEED

with the accurate
SERVO-TEK SPEED INDICATING SYSTEM

A truly versatile "package" provides accurate speed indication for almost anything that moves. Nearly every industrial process or machine can benefit by the economy and safety of continuous speed indication.

FEATURES

- **SELF-POWERED** No batteries or external power required.
- **LOW VOLTAGE** Connecting cable can be as long as 500 ft. for remote readings.
- **PERMANENTLY LUBRICATED BALL BEARINGS** Sealed against foreign particles and harmful vapors.
- **EASILY READ 4½" INDICATOR** Damped to withstand vibration and shock.
- **STANDARD RANGES** 0 to 100, 500, 1000, 2000, 3000, 4000, 6000, 8000, 10,000 and 12,000 RPM. These speeds can also be provided to read "Percent of Full Speed" or "Percent of Capacity."
- **STANDARD (SAE) AUTOMOTIVE AND AIRCRAFT MOUNTS,** as well as special scales, also available.

$87.00 includes generator, indicator (specify range), mounting base, coupling, and 15 ft. of electrical cable. Delivery from stock. Quantity discounts.

Servo-Tek
PRODUCTS CO
INCORPORATED

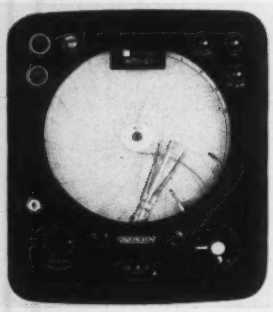
Main Office
1086 Goffle Road, Hawthorne, N. J.

Western Office
14736 Arminta Street, Van Nuys, Cal.

For more information circle **104** on inquiry card.

AUTOMATIC RINSE CONTROL

New Automatic Rinse Control, to provide single-instrument control of major dye kettle operations, opens the rinse valve automatically to flush away spent dyestuffs and chemicals and maintain rinsing until the end of the cycle. A convenience to the

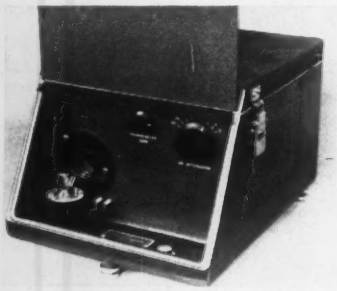


operator, such control eliminates time-consuming supervision and costly waste of rinse water. Optional on new Cycle-Log Controllers (Models 40C-HR, and 40C-HCR), rinse control may also be added to instruments now in service.—*The Foxboro Company, Foxboro, Mass.*

For more information circle **225** on inquiry card.

INFRASONIC AMPLIFIER

New Galvanometer-Phototube Amplifier, Model 4300, employing an optical beam-splitter, twin mutual-load photocells, a cathode-follower output, and a Geotech galvanometer provides a voltage gain of ¼ million, a noise level of less than 0.025 mv,



and an 8-hour drift of less than 0.1 mv rms referred to input with a 5 cps galvanometer installed. Maximum output voltage is 30 v p-p into an open circuit, and 16 v p-p into 10 Kohms.—2-page Bulletin AP-0381 gives details. —*Geotechnical Corp., P. O. Box* 28277, *Dallas* 28, *Texas.*

For more information circle **226** on inquiry card.

SOLID-STATE RELAY

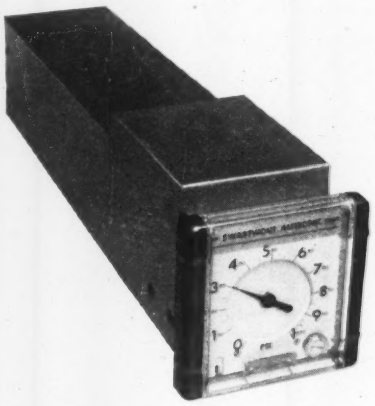
New electronic Solid-State Relay features no moving parts, yet snap action characteristics and 28-vdc coil circuitry. Pick-up is 18 v (pick-up time approximately 5 usec), and drop-out is 11 v (drop-out time approximately 30 usec.).—*Pendar, Inc., Electronic Div., P. O. Box* 3355, *Van Nuys, Calif.*

For more information circle **227** on inquiry card.

Great things are happening in AutroniC® Control

NEW

DIGITIZER



translates analog signal to digital code for telemetering, direct data reduction

With electronic null-balance accuracy, Swartwout's new Indicating-Digitizer directly converts transmitted data on any process variable into a digital code suitable for computation, telemetering, data logging or preparation of punched cards and tape. It indicates the variable, too, and may be operated in parallel with recorders and controllers.

Operating on the standard 0-0.5V AC AutroniC signal, the Digitizer employs a differential-transformer feedback circuit for high-accuracy indication and encoding. Optional, built-in alarm switches provide for wide-range high/low alarm signals.

The entire instrument is packaged in a panel-mounting case that fits into a standard five-inch-square cutout. Calibration adjustments are readily accessible; the entire unit is of plug-in type construction for easy servicing.

Totally new, but thoroughly tried and tested, the Swartwout Digitizer is another advance in the new industrial era pioneered by Swartwout with fully electronic AutroniC Process Control.

For details on the Indicator-Digitizer, request Specification Sheet A-806. The Swartwout Co., 18511 Euclid Avenue, Cleveland 12, Ohio.

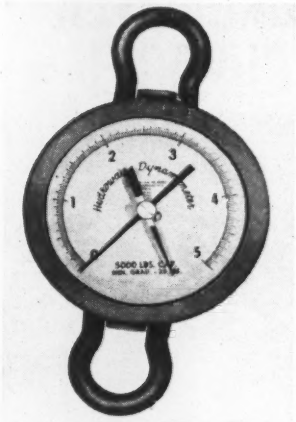
SWARTWOUT

. . . world leader in electronic process instrumentation

For more information circle **105** on inquiry card.

HYDRAULIC DYNAMOMETERS

New 6" portable Dynamometers have a capacity of 0 to 5,000 lb, with a built-in 5:1 safety factor. The maximum movement of the piston (under

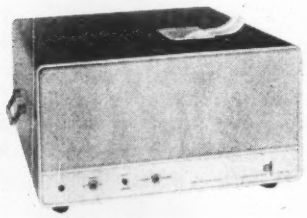


full load) is only 0.032". Available at a slight extra cost is a pre-set pointer, used for setting "not-to-exceed loads." Permanently-sealed, they are weatherproof and maintenance-free.—*Hydroway Scales Inc., P. O. Box* 531, *Oakridge Station, Royal Oak, Mich.*

For more information circle **228** on inquiry card.

DIGITAL PRINTER

New Model 400C automatically prints digital data from high-speed counting, timing, frequency measuring and data-handling equipment. Optional features include: (1) Ten-line output from each digit for operating



card and tape punches and electric typewriters. (2) Analog output for driving strip-chart and other pen-type graphic recorders. (3) Built-in in-line readout for visual monitoring at a distance. (4) Accumulator for final totalizing or totalizing results over a period of time. (5) Code conversion to accept 1-2-4-8 or other codes. (6) A transistorized drive which accepts low voltage input. (7) An add-subtract solenoid which will print plus numbers and minus numbers on command of the basic instrument, and (8) Print-line identification for coding any desired line of printed numbers.—4-page bulletin contains details.—*Computer Measurements Corp., 5528 Vineland Ave., North Hollywood, Calif.*

For more information circle **229** on inquiry card.

OUTSELLS THEM ALL!

HERE'S WHY

1 2½ to 1 ratio – guide length to guide diameter–prevents galling and hanging up.

2 High thermal expansion rate of sleeve guide and low thermal expansion rate of hardened stem retainer eliminates binding and galling even at elevated temperatures.

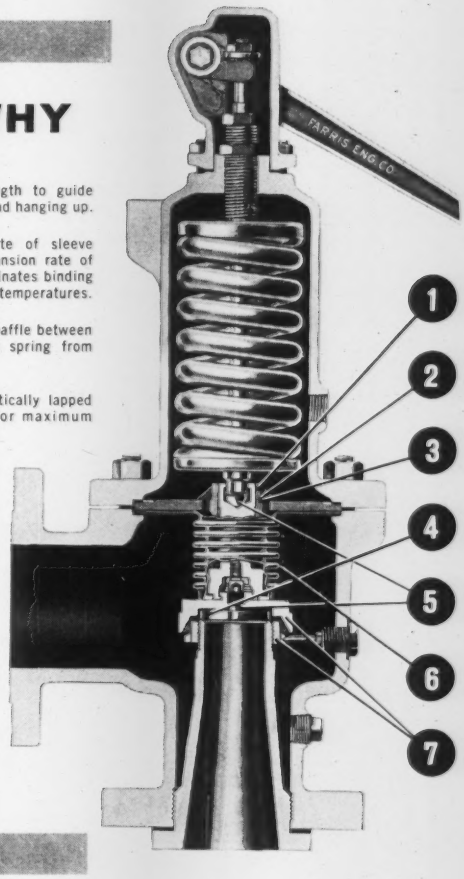
3 Sleeve guide provides solid baffle between body and bonnet, shielding spring from lading fluid.

4 Hardened stainless steel optically lapped flat disc – self aligning for maximum tightness.

5 Double universal ball joint from stem to disc for self alignment – eliminates effects of spring, temperature and piping distortion.

6 Stainless steel "BALANSEAL" bellows nullifies effect of back pressure and isolates internal working parts from lading fluid.

7 Cone-shaped disc holder directs flow away from guiding surfaces and forms fixed secondary orifice with single blowdown ring control for built-in capacity.



Farris full nozzle Safety-Relief Valves

Simplicity in design, safety in operation . . . what more can you ask of a Safety-Relief Valve! The patented design features shown in this Farris valve have been *standard* for more than a decade. It's the ideal concept of a trouble-free, safe, safety valve, free from inventory and design change problems since 1945. It's the *preferred design* in full nozzle safety-relief valves for the process industry.

Detailed information for the selection and sizing of all Farris process safety-relief valves is in Catalog FE-118. Sent to you on request.

PROGRESS THROUGH HONEST PURPOSE

Farris ENGINEERING CORP.

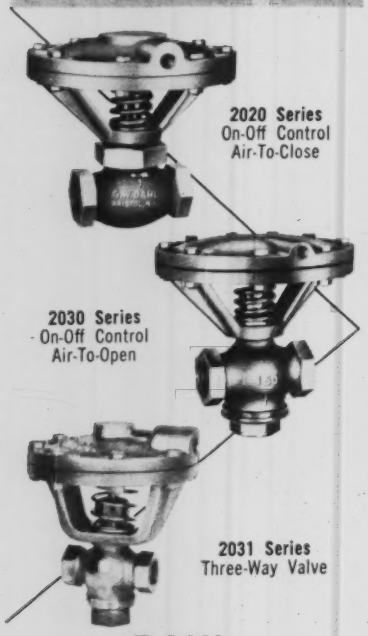
706 Commercial Avenue, Palisades Park, N.J.

Texas Plant: 5405 Clinton Drive, Houston 20

affiliates: FARRIS FLEXIBLE VALVE CORP. • FARRIS PICKERING GOVERNOR CO., INC. • FARRIS ENGINEERING LTD., LONDON, ENGLAND

For more information circle **106** on inquiry card.

A LOT OF CONTROL IN A SMALL SPACE



DAHL "BANTAM" VALVES

Dahl "Bantam" 2020, 2030 and 2031 series are highly compact, diaphragm-operated on-off valves. Each features the desired ruggedness and high quality of larger valves, and yet, allows appreciable savings in space. All have cast globe bodies for steam, liquid or gas applications.

"Bantam" valves have excellent flow characteristics, low hysteresis and fast response. Use of TEFLON® packings eliminates frequent packing adjustment and greatly reduces maintenance.

MAXIMUM Cv	40.0
LIFT	⅝"
SEAT AREA	up to 3.1 sq. in.
CONNECTIONS	¼" to 2" N.P.T.
PRESSURE RATING	150 psi for steam 300 psi for liquid & gas
OPERATORS	8, 15, 50 sq. in.

For more detailed information on "BANTAM" On-Off and Throttling Control Valves write for..... Catalog B-1.

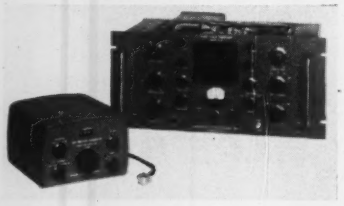
GEORGE W.
DAHL
COMPANY, INC.
86 TUPELO STREET, BRISTOL, RHODE ISLAND

For more information circle **107** on inquiry card.

NEW INSTRUMENTS

NMR FIELD CONTROL UNIT

New nuclear-magnetic-resonance Field Control Unit, Model FC-501, provides means for precise regulation of electromagnets by producing an error signal, derived from the field under control, suitable for closed loop

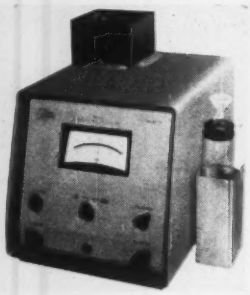


regulation of the magnet power supply. Range is 310 to 20,000 gauss with standard probes. Modulation sweep is zero to 20 gauss.—*Harvey-Wells Electronic, Inc.*, 5168 *Washington St., West Roxbury* 32, *Mass.*

For more information circle **230** on inquiry card.

FLAME PHOTOMETER

New portable Direct Reading Flame Photometer, with clinical applications in hospital laboratories to determine the concentrations of sodium and po-



tassium in samples of blood and other biological fluids, has a unique new feature where Na and K are read directly in Meq/1 from a meter on the instrument. Needs no galvanometer, uses ordinary city or manufactured gas, has an internal standard, and is easily calibrated.—*Baird-Atomic, Inc.*, 33 *University Rd., Cambridge* 38, *Mass.*

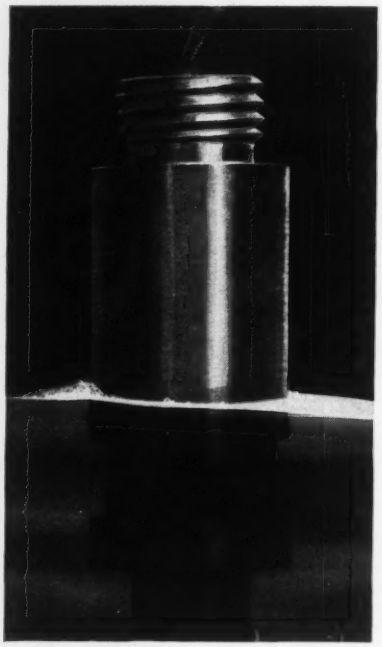
For more information circle **231** on inquiry card.

RADIOACTIVITY MONITOR

New Liquid Monitoring System consists of a liquid sampler, a scintillation detector inserted directly into the liquid stream, a rateméter, a recorder and a choice of accessories for a particular application. Sensitivity ranges from high-level radiation down to tolerance level for liquids. Alarms are available to warn or actuate other devices.—*Tracerlab*, 1601 *Trapelo Rd., Waltham* 54, *Mass.*

For more information circle **232** on inquiry card.

MEASURE FUEL LEVEL WITH MICROMETER ACCURACY!



ACOUSTICA ULTRASONIC continuous gauges and liquid level switches are unequaled for the measurement and control of LOX, kerosene, nitric acid and exotic fuel. Accurate up to 1/64 inch... unaffected by liquid variables... operate instantaneously... consume infinitesimal power... no spark or radiation hazard. Now integrated in major military propellant utilization and liquid control systems. Expert Acoustica engineers can help you with your gauging problems. Send for further information.

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Dept. ICS, 26 Windsor Ave., Mineola, N. Y.

Send information on:
☐ Continuous gauges ☐ Liquid level switches

Name_____
Company_____
Address_____
City_____ Zone____ State_____

For more information circle **108** on inquiry card.

TRANSFER VOLT-AMMETER

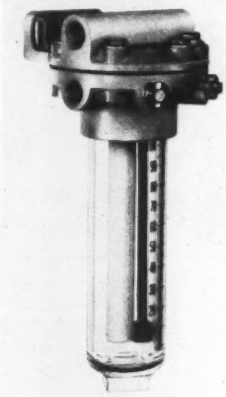
New Hermach-Engelhard Transfer Volt-Ammeter, said to be the world's most accurate commercially available instrument for measuring alternating current and voltage, can be used in the frequency range 20 to 20,000 cps, with an accuracy of ±0.05%. It is a

commercially available a-c volt-ammeter on which the NBS will issue a certificate. It operates on a thermal matching "transfer" principle as indicated by a galvanometer pointer about a null balance position.—*Charles Engelhard, Inc., 850 Passaic Ave., East Newark, N. J.*

For more information circle **233** on inquiry card.

LIQUID CHEMICAL FEEDER

New Micro-H Liquid Chemical Feeder meters, regulates, and feeds liquid chemicals continuously into a liquid stream at flow rates from 0.1 to 4.0 gpd. Semi-automatic, it



features a built-in ejector, a corrosion-proof plastic body, and a porous stone to feed the liquid chemical. Unit is ideal for the hypochlorination of home swimming pools.—*Fischer & Porter Co., 27 Jacksonville Rd., Hatboro, Penna.*

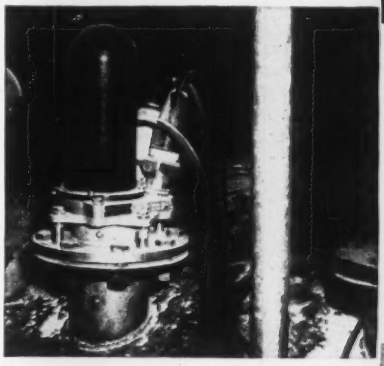
For more information circle **234** on inquiry card.

TIMING GOVERNOR

New Universal Timing Governor features a patented self-starting movement which is housed in a stainless-steel case with a transparent tamper-proof cover. Housing can be attached easily to an associated device and easily removed for servicing.—*Precision Products, Inc., 530 S. Quaker, Tulsa 20, Okla.*

For more information circle **235** on inquiry card.

YES, NOW VISCOSITY

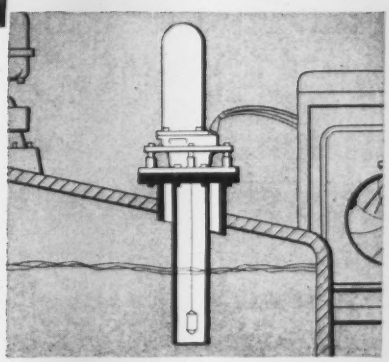


CAN BE CONTINUOUSLY

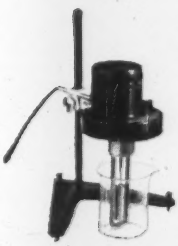
PROCESS CONTROLLED

WITH THE

BROOKFIELD VISCOMETRAN



UNDER actual process conditions, the Brookfield Viscometran accurately and continuously measures, records and controls viscosity. Readily mounted and integrated in existing processes, the Viscometran offers significant economic advantages over other methods of indicating degree of reaction, degree of polymerization or determination of process end point.



Viscosity is very likely a variable that is fundamental in your process. For complete information about how the Brookfield Viscometran can provide continuous "in process" measurement of this product dimension for you, write—

THE WORLD'S STANDARD FOR VISCOSITY MEASUREMENT AND CONTROL

Brookfield

ENGINEERING LABORATORIES, INCORPORATED

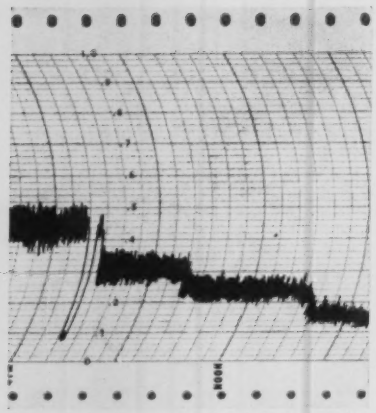
STOUGHTON 316, MASSACHUSETTS

BROOKFIELD VISCOMETRANS NOW SUCCESSFULLY USED FOR CONTROLLING:

Asphalt • Caramel • Cement slurries • Durezresin-acetone slurries • Gluten slurries • Lignum-based polymers • Molten P_2S_5 • Paper coatings • Polystyrene • Polyurethane resins • Ureaformaldehyde resin

For more information circle **109** on inquiry card.

RECORDERS WORK... WHILE YOU ARE BUSY ELSEWHERE



Courtesy Nuclear Measurements Corp., Indianapolis, Indiana

This record was made by a DC Milliammeter in a monitoring unit, measuring fall-out over Indianapolis after the explosion of an experimental bomb.

The recorder was on the job continuously for 1½ days before fall-out began to increase as shown here. Meanwhile the technicians and engineers were busy at other tasks.

Make recording instruments help you multiply your effectiveness. Ask for Catalog 657.

Product Representatives in Most Principal Cities

The ESTERLINE-ANGUS Company, Inc.

Pioneers in the Manufacture of Graphic Instruments

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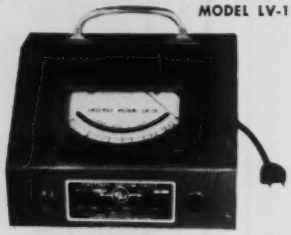
For more information circle **110** on inquiry card.

HASTINGS VACUUM GAUGES

SET NEW STANDARDS OF ACCURACY, STABILITY, RESPONSE

MODEL LV-1

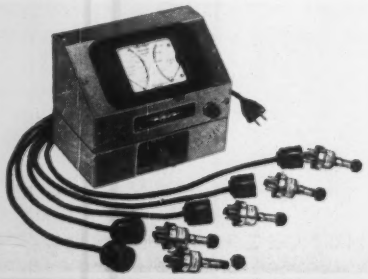


- Easy To Read Scales
- Unusually Long Life
- Matched Gauge Tubes
- No Outgassing Or System Contamination

NEW MODEL LV-1. Measures 0-100 micron Hg. Single meter; large 4" scale indicates vacuum directly without adjustments. Internal voltage regulator takes care of fluctuations in line voltage. Ideal for Industrial Installations. Also available in 0-1000 micron and 0 1-20 mm Hg. ranges.

MODEL GV-3 VACUUM GAUGE

(Shown at right with optional 5-position switching attachment) Range from 0-1000 microns Hg. Manual current set and additional milliampere scale allow adjustment for use in presence of gases other than air, for leak detection, and for specialized laboratory use.



Evaluation by Users

PROVES SUPERIORITY

of Hastings Gauges

WRITE:

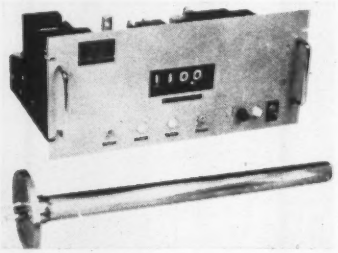
HASTINGS-RAYDIST INCORPORATED

HAMPTON 10, VIRGINIA

For more information circle **111** on inquiry card.

LIQUID-LEVEL GAGE

New Model 0358-1 Liquid Level Gage continuously measures a wide range of liquids and granular solids. Accuracies of as high as 0.1" over a 10-ft range can be achieved. All-electronic, it employs a capacitance circuit. The gage is suitable for a wide

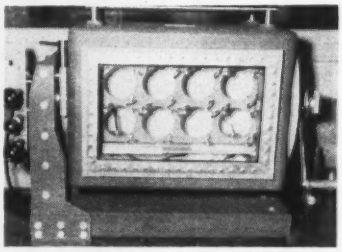


range of electrically-conductive liquids and granular solids, such as kerosene, liquid oxygen, water, nitric acid, and grain. Readout can be in dial or counter form or be built into a standard 11" strip chart recorder.—*Magnetic Instruments Co., Inc., 546 Commerce St., Thornwood, N. Y.*

For more information circle **236** on inquiry card.

TEST CHAMBER

New Model 16-13-8 is designed to test 8 instruments at one time, equipped with valves for pressure,



vacuum and vent has double door insuring positive seal and safety feature. Operating pressure range is 0.005" to 100" Hg, abs.—*Ideal-Aerosmith Inc., 3913 Evans Ave., Cheyenne, Wyo.*

For more information circle **237** on inquiry card.

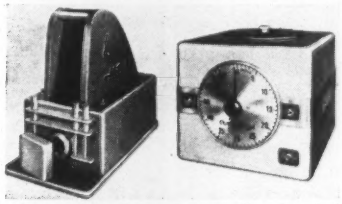
STAINLESS ADAPTERS

New stainless-steel Dryseal-pipe-threaded Adapters (not to be confused with ordinary pipe fittings) are made to Parker drawings, precision-machined under strict quality control methods from Type-316 forgings and barstock. Items available include the standard shapes: connector, reducing-connector, thread-reducer, nipple, elbow, 45° and 90° street elbows, tee, and cross. Size range is from ⅛" through ½" pipe thread.—*Parker-Hannifin Corp., Parker Fittings & Hose Div., 17325 Euclid Ave., Cleveland 12, Ohio.*

For more information circle **238** on inquiry card.

PARTICLE SIZE ANALYZER

New Particle Size Analyzer System for particles between approximately 0.1 and 40 microns (which include most airborne dusts, paint pigments, and many flours, chemicals and pharmaceuticals) comprizes special centrifuge tubes and a tube feeding chamber, an optical tube projector, and one or more special centrifuges. A magnified image of the sediment column in a centrifuge tube is measured on a graduated screen of the

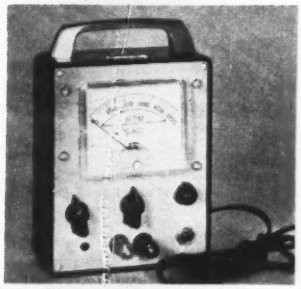


M-S-A optical projector. Basic steps in particle analysis are preparation of a suspension of particles, transfer of suspension to the feeding chamber and then into a centrifuge tube in such a way as to leave a sharp layer of the suspension on top of the sedimentation liquid. Sediment height is read before and after centrifuging at predetermined times and speeds. Size distribution is determined from sediment height data.—Bulletin 0709-1 contains details.—*Mine Safety Appliances Co., 201 N. Braddock Ave., Pittsburgh 8, Pa.*

For more information circle **239** on inquiry card.

TRANSISTORIZED TACHOMETER

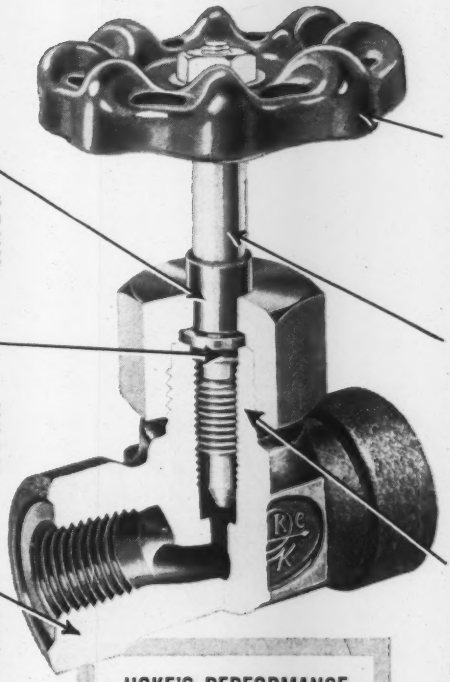
New Transi-Tach Transistorized Tachometer is available in three basic models—for 19" rack panel mounting, as a portable unit, or with remote indicator. All models are self-powered by a 9-v battery, but can also be used with 115, 60-cycle ac. Speed of rotating shafts is indicated through the use of a magnetic or other speed pick-up. Rpms are read directly up to



60,000. Since it is essentially a frequency meter, it can be supplied for the measurement of audio or ultrasonic frequencies. It may also be adapted for use in conjunction with any transducer which converts flows, pressures, or other physical forces into electrical signals of variable frequencies. Accuracy is ± 2% of full scale.—*Kahn and Co. Inc., 547 Windsor St., Hartford 1, Conn.*

For more information circle **240** on inquiry card.

LOW COST FLUID CONTROL at HIGH PRESSURES
(and low, too)



EXCLUSIVE NYLON STEM WIPER
Positively prevents foreign matter from scratching or pitting stem, harming O-ring seal.

GUARANTEED LEAK-PROOF O-RING SEAL
Forget about packing adjustments, leaks through stem with tough, pliable O-ring seal.

FORGED CARBON STEEL BODY
Heavy duty, weldable carbon steel body in globe or angle patterns, selection of male or female connections.

DIE-CAST ALUMINUM HANDWHEEL
Easy grip, non-slip, die-cast handwheel gives you smooth turning down for quick, accurate flow control.

CENTERLESS GROUND STEM
Stainless steel, centerless ground stem assures perfect fit, positive shut-off.

SAFE, INTEGRAL BONNET
One-piece, forged steel body and bonnet insures against blow-out, gives added measure of safety.

HOKE'S PERFORMANCE GUARANTEE —
Every Valve Leak-Tested!

SERIES 100 FORGED NEEDLE VALVES

FREE: A sample valve is yours for the asking. Put this heavy duty, versatile valve to the test on hydraulic lines, manifolds, air lines, test stands. Use it for regulating or shut-off of water, oil, gas. Temperature range –40 to 200°F. Pressure rating: vacuum to 10,000 psi. Write to us on your company letterhead for the full story and your FREE SAMPLE VALVE.

See Our Catalog in Sweet's Product Designer's File

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Fluid Control Specialists
31 PIERMONT RD., CRESSKILL, N.J.

For more information circle **112** on inquiry card.

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For more information circle **113** on inquiry card.

Miniature **FAST-RESPONDING** Surface **THERMOCOUPLE**

New Design Features Offer for the First Time a Thermocouple with:

- A Response Time of Less than 10 Microseconds
- A Maximum Continuous Service Temperature of Over 2000°F.
- An Operating Pressure Range to 50,000 psi
- A Sensing Tip with Indefinite Life

Revolutionary design uses thin ribbon thermocouple wires and mica insulation of .0002 inches thickness. Will operate under extremely high velocity and high pressure conditions.

Available in iron-constantan, chromel-alumel, or platinum-platinum/10% rhodium standard thermocouple elements.

For additional details and models write for Bulletin No. TB 159.

NANMAC CORPORATION
P. O. Box 8, Indian Head, Md.

For more information circle **114** on inquiry card.

MEASUREMENTS' *New* STANDARD PULSE GENERATOR

MODEL 179

The Model 179 is uniquely suited for production and laboratory work where pulses of known repetition rate and width are required. It is extensively used in TV, radar, computer and nuclear fields.

- Wide, calibrated frequency range — 60 cps to 100 Kc
- Continuously variable calibrated pulse width
- Triggered and free-running operation
- High-amplitude positive and negative pulses . . . +200 v to −150 v

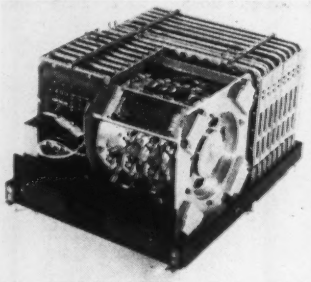
Laboratory Standards WRITE FOR BULLETIN

MEASUREMENTS
A McGraw-Edison Division
BOONTON, NEW JERSEY

For more information circle **115** on inquiry card.

AIRBORNE DIGITAL COMPUTER

New AN/ASN-24 lightweight airborne, multi-functional silicon-transistorized Digital Computer is immune to a wide range of environmental extremes. The set includes a versatile control console, a digital computer and

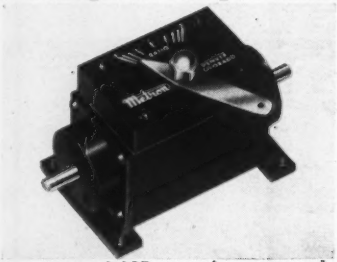


a bearing-distance indicator. It handles data from TACAN, celestial, inertial, and Doppler information; radio, true-airspeed systems, and heading instruments.—*Librascope, Incorporated, 808 Western Ave., Glendale, Calif.*

For more information circle **241** on inquiry card.

MINIATURE SPEED CHANGER

New miniature adjustable-ratio Speed Changer, Series 2, has stainless-steel input- and output-shafts of $\frac{3}{16}$" dia, running in double heavy-duty shielded ball bearings. The toroidal-disc drive is manufactured from 52100 ball-bearing steel. Ratings: maximum



hp output—0.025; maximum speed—10,000 rpm; speed adjustability—ratio continuously variable from 1:5 up to 5:1 down (25:1 overall range); torque output—5 to 40 in-oz depending on the ratio setting.—*Metron Instrument Co., 432 Lincoln St., Denver 3, Colo.*

For more information circle **242** on inquiry card.

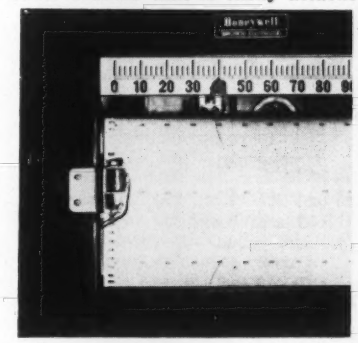
MULTI-CONDUCTOR CABLE

New Thermo-Cable polyvinyl-insulated cable for 6 to 56 pairs of thermocouple conductors is much easier to handle and less expensive to install than individual pairs of thermocouple extension wire. Aluminum-backed Mylar tape, wrapped around the conductor bundle, provides electro-static shielding. Each conductor is color-coded, and all cables contain a copper wire which serves as either a ground or communications wire. Multi-junction terminal boxes are also being made available.—*Thermo Electric Co., Inc., Saddle Brook, N. J.*

For more information circle **243** on inquiry card.

MINIATURIZED COUNTER/PRINTER

New Miniature Indentichart, Model RI-1-A, is a single-digit, ten-positions Chart Marker that is easily attached

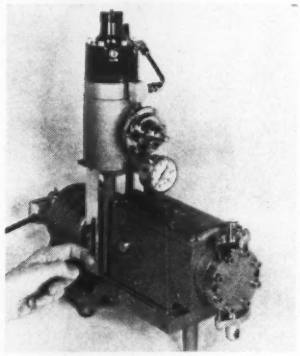


to any type strip chart recorder. It is a simplified version of the standard multiple-digit RI-1-Serial printer used as a print-out device on all makes of recorders.—*Royson Engineering Co., Hatboro, Penna.*

For more information circle **244** on inquiry card.

AUTOMATIC METERING PUMP

New Automatic Metering Pump, called Auto-Pneumatic Micro-flo Pulsafeeder, that adjusts pumping rate from zero to full capacity by 3 to 15-psig control signals has theoretical capacity ranges from 1040 to

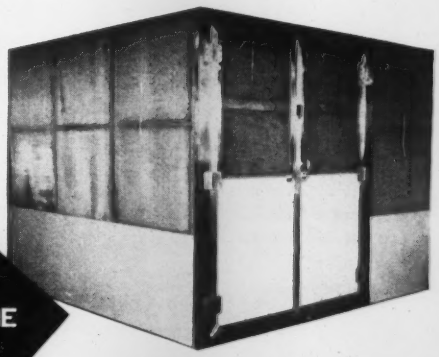


2300 ml/hr at 0 psig. Pressures up to 2,000 psig can be accommodated. The positive-displacement-type pump is equipped with a positioner for accurate push-rod positioning.—*Lapp Insulator Co., Inc., Process Equipment Div., 100 Hall St., LeRoy, N. Y.*

For more information circle **245** on inquiry card.

256-CHANNEL ANALYZER

New completely-transistorized 256-Channel Analyzer, Model CN-110, features interchangeable plug-in logic units for: (1) pulse height analysis, (2) neutron time of flight studies, and (3) counting as a function of time (decay measurements, etc.); also a 3" CRT display on front panel, analog address and arithmetic readout, pre-set count, and average dead time (with pulse height analyzer unit) of



NOW RADIO INTERFERENCE TESTING HAS BEEN ADDED!

ACTON LABORATORIES COMPLETE ENVIRONMENTAL TESTING LABORATORIES PROVIDE RADIO INTERFERENCE TESTING PLUS CONSULTING SERVICES.

Qualification testing to meet military and Federal Communication Commission specifications service includes: field intensity measurements, RF interference measurements in accordance with commercial and military requirements, antenna pattern analysis, determination of harmonic spurious frequency output of transmitters, local oscillator radiation of receivers and determination of shielding effectiveness.

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Acton's Environmental Testing Laboratories are staffed by experienced personnel with the important "know-how."

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Subsidiary of TECHNOLOGY INSTRUMENT CORP.

Dept. E-6, 521 Main Street • Acton, Massachusetts

For more information circle **116** on inquiry card.

POST DECITRON ELECTRONIC PRODUCTS

Now . . . low cost . . . accurate "batch" counting for small products.

The *PORTABLE* FCB-1

The Post FCB-1 is a sorting and counting device which incorporates a Syntron vibrator with a Decitron Preset Counter. Model illustrated utilizes a P2 counter, capable of 'batch' counting small objects in any quantity from 1 to 100.

Very small products can be neatly separated on the special conveyor belt . . . individually counted . . . dropped into a 'hold' tray and when the desired count is reached, the entire batch is fed into a waiting box, bag or other container. This latest Post development will feed 300 to 1000 pieces per minute and is **portable!** Size: only 53" long, 18" high, 12" wide. Cost as shown, $3500.

Post will be glad to furnish quotations for models capable of counting larger batches.

Decitron

POST ELECTRONICS

Division of Post Machinery Co. | 165 Elliott St., Beverly, Mass.

For more information circle **117** on inquiry card.

modern, low-cost way to precision measurements . . .

AEROVOX DECADE BOXES

Inductance, Resistance and Capacitance Decades in extra-compact and rugged design for accurate and dependable performance. Quality components used throughout to provide the same precise quality standards, electrically and mechanically, as finest lab-type equipment.

Units housed in heavy-duty, seamless steel cases with durable gray finish. All one size—5⅛"L x 3⅛"W x 2 13/16"H. Black face plates with white markings. Highest value multiplier on left.

Available from all Aerovox Parts Distributors, write for descriptive literature...

AEROVOX CORPORATION

DISTRIBUTOR DIVISION

New Bedford Massachusetts

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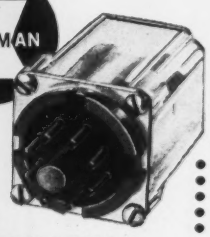
KURMAN

SERIES 26D 10 AMP.



KURMAN

MINIATURE POWER RELAY

FEATURES

- Clear polystyrene dust-proof enclosure
- Up to 3 P D T, 10 amp. contacts
- AC or DC coil, up to 15,000 ohms
- Life—100,000 operations minimum
- Dimensions 1⅜" sq. x 2¼" high
- Octal or 11 pin plug-in

STOCKED BY LEADING DISTRIBUTORS FROM COAST TO COAST

For Immediate Delivery at Factory Prices

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Division of Norbute Corp.

Quality Relays Since 1928

191 NEWEL ST.

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Export: 135 Liberty St, N.Y.

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KURMAN

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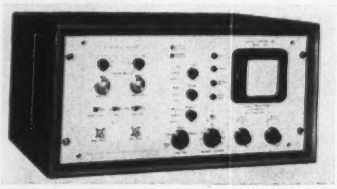
For more information circle **119** on inquiry card.

42 usec. The basic unit contains a complete magnetic-core data-storage system. Various methods for data readout that can be used include analog, binary, octal, and decimal read-

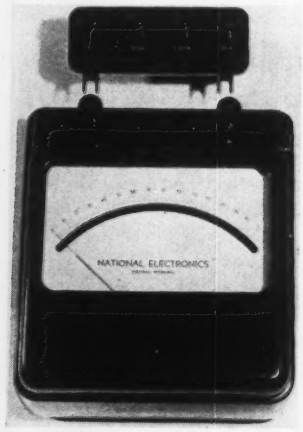


out on strip chart and X-Y recorders, printed and magnetic tape, punched tape, and cards.—*Technical Measurement Corp., 441 Washington Ave., North Haven, Conn.*

For more information circle **246** on inquiry card.

D-C AMMETER-VOLTMETER

New portable D-C Ammeter-Voltmeter, with self-shielded D'Arsonval (moving coil) movement and 49 possible ranges, features accuracy of better

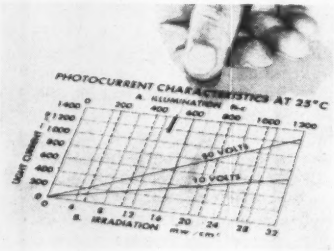


than 0.5% on all divisions of the scale at an ambient temperature of 25°C, a spring shock-mounted movement and precise series resistances and shunts which do not effect the rated accuracy.—*National Electronics, Sheridan, Wyo.*

For more information circle **247** on inquiry card.

SUBMINIATURE PHOTO-DUO-DIODE

New 1N2175 subminiature light-sensing diffused N-P-N Photo-Duo-Diode allows current flow when either junction is exposed to light, but ef-

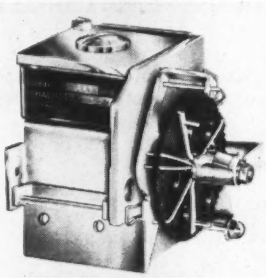


fectively shuts current off in darkness. When exposed to 1200 foot-candles of light it passes up to 1200 microamps, in darkness it passes less than 0.5 microamps. Dissipation is rated at 250 mw at 25°C and any bias up to 50 v will operate the device equally well on either ac or dc.—*Texas Instruments Incorporated, P. O. Box 312, Dallas, Texas.*

For more information circle **248** on inquiry card.

DIGITAL DECODER

New electro-mechanical Decoder, Model HS-59, is energized by d-c pulses which cause an electro-magnet to drive a notched code wheel one step for each pulse. It can be set to respond to any one of twenty million combinations of coded digital pulses

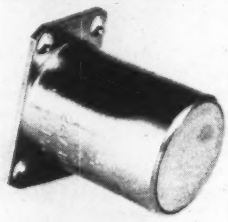


and is customarily actuated by a telephone dial or an electro-mechanical or electronic encoder. Its capabilities include (1) nationwide mobile telephone dialing, (2) world-wide marine telephone dialing, or (3) control systems of almost infinite capacity.—*Secode Corp., 555 Minnesota St., San Francisco 7, Calif.*

For more information circle **249** on inquiry card.

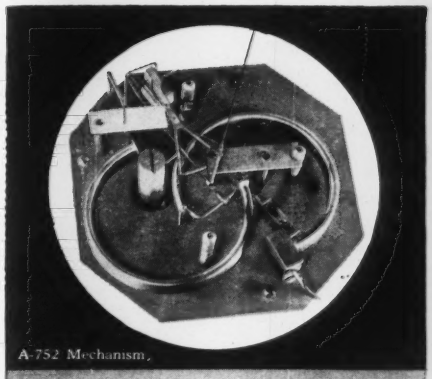
MINIATURE SOLENOID

New ultra high-speed Miniature Solenoid, Model RS 5178, has 0.015" stroke and will operate with a 10-lb load. Motion will start at a maximum



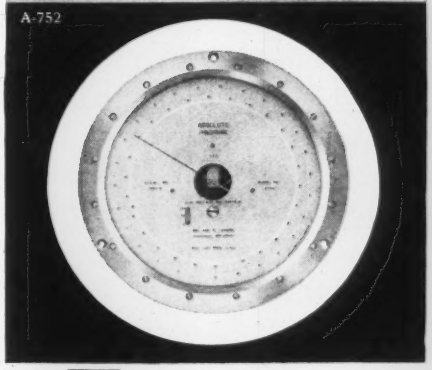
of 6 msec and the stroke will be completed at less than 13 msec from closing circuit. The solenoid requires 20 vdc at 78°F. Size is 1.410" height x 1.063" dia. Because of extremely close tolerances it is manufactured in a completely controlled atmosphere.—*Telecomputing Corp., Telco Electronic Sales Div., 915 North Citrus Ave., Los Angeles 38, Calif.*

For more information circle **250** on inquiry card.


A-752 Mechanism

NEW W&T BOURDON TUBE GAUGE

A-752



liquid column accuracy beyond liquid column range

A combination of Ni-Span-C* Bourdon tubes, a special ratio linkage and custom calibration set these W&T gauges apart. Use of corrosion-resistant Ni-Span-C eliminates temperature compensation, makes the gauge usable in a wide variety of applications. Dual Bourdon tube mechanism provides high accuracy measurements of absolute or differential pressures without applying any system pressure to the gauge case. The special ratio linkage provides low friction, practically no hysteresis. Custom calibration means rapid, accurate readout, as in all W&T precision pressure instruments.

W&T Bourdon tube gauges have:

Max. Range—0-500 p.s.i.; absolute, gauge or differential
Min. Range—0-30 p.s.i.; absolute, gauge or differential
Sensitivity—1:8000
Accuracy—0.2% of full scale range
Hysteresis—negligible
Temperature effect—0.075% of range/10°C

For full information and technical data address Dept. **A-123.48**

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M-32

MERCHEN GRAVIMETRIC FEEDERS & METERS

for dry free-flowing materials

- automatic batch control
- continuous blending
- materials accounting

Accuracy 1%
Rates 3 to 3000 lbs. per min.

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For more information on Bourdon Tube Gauge circle **120** on inquiry card.
For more information on Feeders & Meters circle **121** on inquiry card.

Measure any temperature from −200°F. to +600°F. with one instrument

Thermotest is the all-purpose testing instrument for precise measurement of temperatures from −200°F. to +600°F., and emf's up to 20.1 millivolts. It's the only portable potentiometer with interchangeable direct reading scales *and* automatic compensation. Measurements are read directly from the scale without charts, graphs or conversion tables. Scales interchangeable in seconds for use with three types of thermocouples. Mercury battery power supply. Leatherette covered case. Dimensions: 12¼" x 9" x 8½". Weight: 14 lbs. Write for free bulletin.

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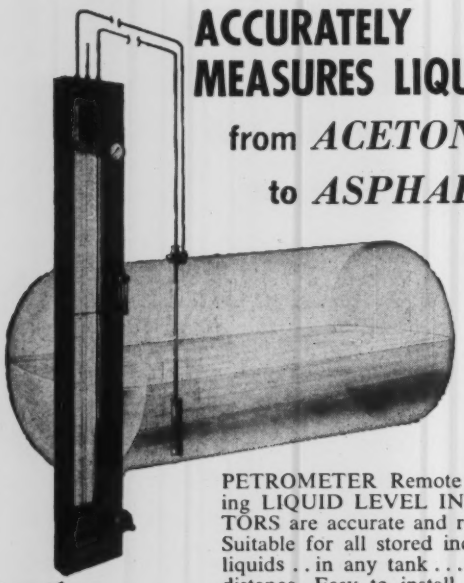
A Division of Duncan Electric Co., Inc.

P. O. BOX 91 • INDIANAPOLIS 6, INDIANA

For more information circle **122** on inquiry card.

ACCURATELY MEASURES LIQUIDS from *ACETONE* to *ASPHALT*



PETROMETER Remote Reading LIQUID LEVEL INDICATORS are accurate and reliable. Suitable for all stored industrial liquids . . in any tank . . . at any distance. Easy to install . . . and easy to read. Indicators have many unique design features.

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For more information circle **123** on inquiry card.

new plants and mergers

HYDROMATICS has doubled its manufacturing space by expansion into a second building nearby.

SERVOMECHANISMS and **LABORATORY FOR ELECTRONICS** have a merger plan under consideration.

LITTON INDUSTRIES has bought the **TIMES FACSIMILE CORP.**, a subsidiary of the New York Times Co.

SIE (Southwestern Industrial Electronics Co.) has opened a new 300,000-sq-ft R&D and manufacturing facility in Houston, Texas.

RADIATION INC. and **LEVINTHAL ELECTRONICS** have announced a proposed merger.

LAND-AIR, INC. has acquired Tammen & Denison, a firm of consulting engineers and industrial designers.

MIDWESTERN INSTRUMENTS recently announced creation of a new Servo Product Division.

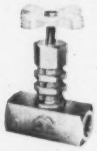
GENERAL ELECTRIC CO. recently opened new headquarters and the laboratory of its Computer Department in Phoenix, Arizona.

MINNEAPOLIS-HONEYWELL's Heiland Div. has expanded its facilities for the second time in two years.

First choice of the rocket and missile industry...

Three superlative Marsh products are widely used and approved by the aircraft and missile industry:

MARSH Pressure Gauges...
because they combine the most advanced features ever found in pressure, vacuum and compound gauges. There is a Marsh Gauge for every conceivable application.



MARSH Needle Throttling Valves...
because they are guaranteed to give micrometer regulation at HIGH pressures—pressure up to 10,000 psi—and any temperature up to 500° F.

MARSH Dial Thermometers...
because they offer the precision and accuracy a precision industry demands. Most complete line; wide temperature ranges, dial sizes, patterns, finishes.

All Marsh products available with AND threads

MARSH *New catalog covers all details*

MARSH INSTRUMENT CO. *Sales Affiliate of Jas. P. Marsh Corp.* **Dept. 42, Skokie, Ill.**
Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada. Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

For more information circle **124** on inquiry card.

people in the news

D. T. Treganowan

R. L. Nelson

C. S. Cotton

HAGAN CHEMICALS & CONTROLS has made the following appointments within its new Controls Div: *John E. Duesing* has been named general manager; *Robert E. Blackwell* has become manager of sales, steel; *Robert L. Nelson* has been appointed manager, product engineering; and *Charles S. Cotton, Jr.*, has been named assistant to the sales manager of the division.

David T. Treganowan has been named public relations manager of Hagan and its divisions, Calgon Co. and Hall Labs.

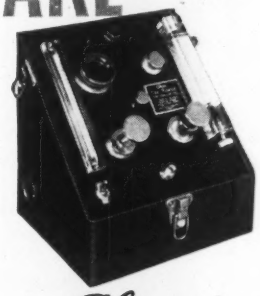
ELGIN NATIONAL WATCH CO. has appointed *Robert DeDobbelaere* product sales manager—carbide tools for the Abrasives Div.

CLAROSTAT announces that *E. W. Kingsbery, Jr.* has joined the company as general sales manager.

GPL has elected *Walter C. Cooper* assistant vice president.

W.&L.E. GURLEY announces election of *M. Scott Dickson* as vice president.

TAKE GUESSWORK OUT of DEW POINT READING with Alnor® DEWPOINTER



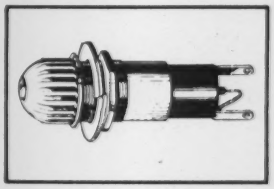
Any shop man can quickly...accurately...read dew points with the Dewpointer. It is the only instrument that lets you see the fog in a sealed chamber under controlled conditions. Compare this fast, positive method with attempts made to tell exactly when fog forms on a mirrored surface. Completely self-contained, requires no external coolant or auxiliary apparatus ...operates on enclosed battery or AC. Available in three ranges for dew points between −20° F. and room temperature, from −80° to 0° F. and −80° F. to room temperature.

Send for Dewpointer bulletin. Tear out this ad and send on your letterhead to: Illinois Testing Laboratories, Inc., Room 518, N. LaSalle St., Chicago 10, Ill.

Alnor PRECISION INSTRUMENTS FOR EVERY INDUSTRY

For more information circle **125** on inquiry card.

Now—*20 TIMES BRIGHTER* Neon Indicator Light Assemblies!



This DRAKE Assembly — No. 101N-022 — is ideal fo use with the new G.E. NE-51H High Brightness Neon Glow Lamp, for 125V AC operation. According to the manufacturer, the lamp gives 20 times more illumination than old style neons. Since useful life is 5000 hours, replacement is made easy with Unit No. 101N-022; bulb flickering warns of time to change. Less than ¼ watt power required for operation.

No. 101N-022 has built-in 22,000 ohm resistor — is available with plain or fluted glass or plastic domed lenses, solder or screw terminals. Also available for 250V application (Unit No. 101N). Commercial units are UL listed. This style can be supplied to meet MIL specs.

DRAKE

★ SEND FOR FREE SAMPLE, DATA SHEET, and Quick-Reference Catalog of other Assemblies and Lampholders in the big DRAKE line.

DRAKE MANUFACTURING COMPANY
1711 WEST HUBBARD ST. • CHICAGO 22, ILL.
MINIATURE LIGHTING SPECIALISTS

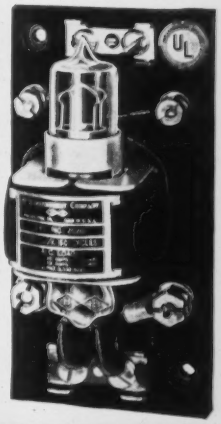
For more information circle **126** on inquiry card.

20 MILLION MAKES-AND-BREAKS WITHOUT MAINTENANCE

That is the actual trouble-free performance record of an H-B Mercury Plunger Relay installed in a municipal system almost nine years ago!

Each make-and-break in an H-B Relay pulsates between automatically renewed, clean surfaces in a sealed, non-corrosive tube. Action is rapid and silent. No burning or pitting is possible. There are no contacts to file, no springs to adjust—and no parts to wear, bind or freeze.

Specify H-B Relays for maintenance-free operation!



WRITE FOR CATALOG

H-B INSTRUMENT CO.

4302 N. American Street
Philadelphia 40, Pa.

H B Mercury Plunger RELAYS
reduce relay maintenance

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DIAPHRAGM GAUGE

FOR ACCURATE PRESSURE MEASUREMENT IN OUNCES OR INCHES OF WATER

Marshalltown Figure 83 is an extremely sensitive gauge that uses a carefully seasoned bronze diaphragm to accurately measure very low pressures. It is used extensively on many types of natural gas installations for checking low pressures.

Available in standard dials (reading in inches of water) 0-15" -0-30" -0-60" -0-100" -0-160" . . . also in ounce graduated dials from 15 ounces to 5 pounds. 2½", 3½" and 4½" dial sizes mounted in black enameled steel case.

Write for details and price. LOOK TO MARSHALLTOWN FOR ONE OE THE MOST COMPLETE LINES OF INDICATING PRESSURE GAUGES MADE!

MARSHALLTOWN MFG. COMPANY
MARSHALLTOWN 3, IOWA

For more information circle **128** on inquiry card.

PEOPLE—CONTINUED

G. A. Stiftinger J. M. Ruffner B. Carlin R. E. Barnett

FISCHER & PORTER has named *G. A. Stiftinger* district manager of the Pittsburgh office.

FENWAL INCORPORATED has promoted *John M. Ruffner* to industrial sales manager.

CIRCO ULTRASONIC CORP., the newly formed subsidiary of Circo Equipment Co., has appointed *Benson Carlin* vice president and executive director.

JAS. P. MARSH INSTRUMENT CO. has elected *Robert E. Barnett* vice president.

NON-LINEAR SYSTEMS announces appointment of *Peter J. Van Benschoten* as sales manager.

P. R. MALLORY & CO. has announced appointment of *T. M. Fitzgerald* as general manager of the electronics division.

TELECOMPUTING CORP. announces that *H. R. "Dick" Alexander* has been appointed director of field engineering for the Whittaker Controls Division.

JEWELS *for* INDUSTRY. . .

By MOSER JEWEL COMPANY, pioneer industrial jewel manufacturer for over 50 years.

- HIGHLY POLISHED STEEL PIVOTS AND STAFFS
- HARD ALLOY WELDED TIPS
- NON-MAGNETIC STAFFS
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FOR INFORMATION ON HOW WE MAY FILL YOUR REQUIREMENTS

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CERAMIC
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COPPER
*CORNING 707
*CORNING 7052
CUPROUS BROMIDE
FERRITE
FERROX
**FLUORIDE, CALCIUM
**FLUORIDE, LITHIUM
GALLIUM ANTIMONIDE
GALLIUM ARSENIDE
GARNET
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GOLD
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LITHIUM FERRITE
MAGNETIC PLUMBITE
MELAMINE FIBER GLASS
MICA, SYNTHETIC
NICKEL OXIDE
PLATINUM
POTASSIUM BROMIDE
*PYREX
*QUARTZ, CRYSTAL
*QUARTZ, FUSED
**SAPPHIRE
**SODIUM CHLORIDE
**STEEL
STRONTIUM TITANATE
TEFLON
TITANIUM DIOXIDE
*VYCOR
*X-RAY LEAD GLASS
ALL TYPES KNOWN GLASS

* Carried in stock
** Purchased for orders

For more information circle **130** on inquiry card.

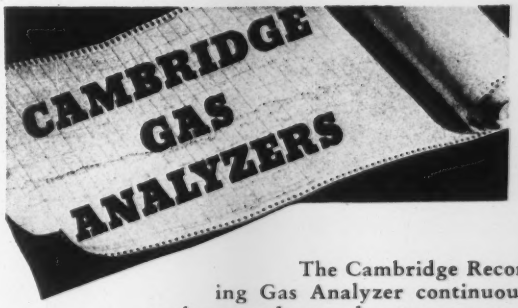
PACIFIC SCIENTIFIC CO. has elected *George J. Pandapas* a director. He is president and board chairman of **ELECTRO TEC CORP.**

SANDERS ASSOCIATES have appointed *Edward A. Beaupre* assistant to the vice president, operations.

SAMA announces that *Hampton M. Auld* has resigned as executive secretary of the Recorder-Controller Section; *L. D. Stickles*, legal counsel of the section, and partner in the firm McLaughlin, Stickles, McKean & Hayden, is continuing to serve as acting secretary; *J. R. Irving* has been named executive secretary of the laboratory equipment section, and that *Nicholas G. Geannopulos* has been appointed director of public information.

John M. Roberts

John M. Roberts, former president of SAMA and one of its founders passed away February 20 at the age of eighty-seven. His death was caused by a broken hip followed by complications. Mr. Roberts was a partner in the Central Scientific Company of Chicago at the time SAMA was organized in 1918. He was elected secretary at the first session that year. He served as member secretary until 1929 when he disposed of his interest in the ownership of Central Scientific and became staff manager of the Association. He occupied this position, being given the title of president in 1937, until he retired in 1948. He is survived by two daughters, a brother, and five grandchildren.



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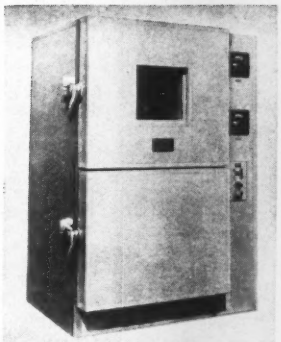

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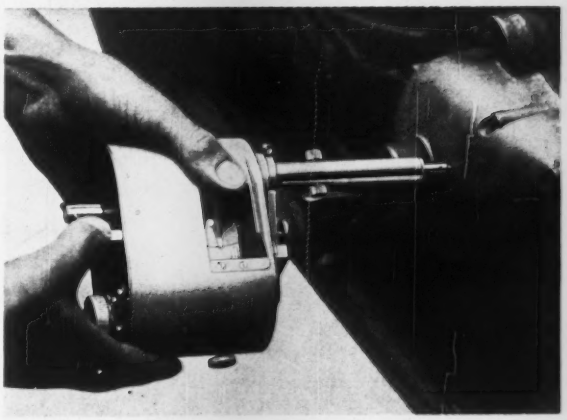

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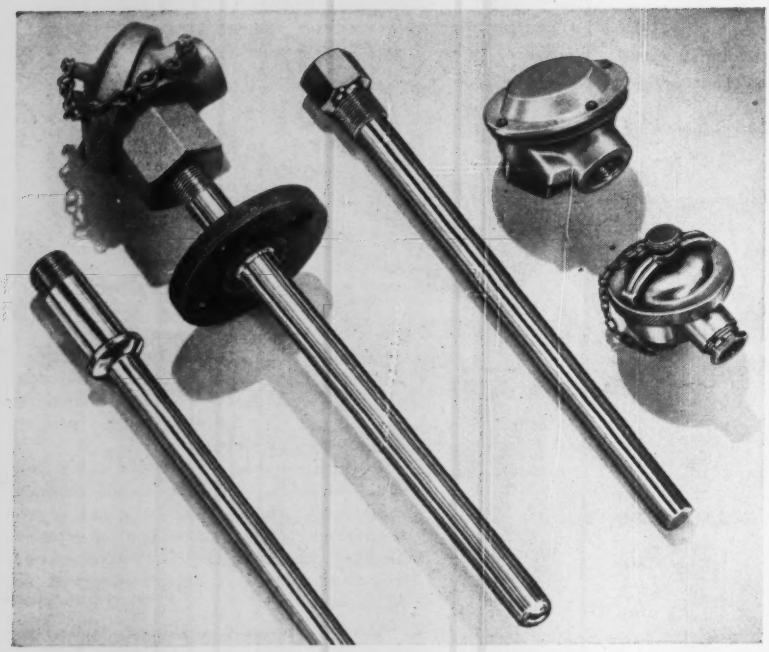

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For more information circle **134** on inquiry card.

new literature

CONTROL SYSTEMS

PROCESS CONTROL SYSTEM. 16-page brochure tells how to calibrate the newest types of process control systems particularly those which use proportional currents for signal transmissions and telemetering.—Technique Associates, Inc., 1413 North Cornell Ave., Indianapolis 2, Ind.

For more information circle **251** on inquiry card.

CUSTOM CONTROL CENTERS. 4-page brochure illustrates and describes typical Condeco custom control centers for all types of automation systems and automatic machinery.—Control Design and Fabricate, Inc., 30725 Twelve Mile Rd., Farmington, Mich.

For more information circle **252** on inquiry card.

VALVES AND ACTUATORS

CONTROL VALVES. 4-page Bulletin 581 describes 3-way and 4-way Slim Line control valves, which are only 1" thick by 3" wide; mount conveniently on any machine, and are easily manifolded into compact control centers.—Hunt Valve Co., Salem, Ohio.

For more information circle **253** on inquiry card.

HIGH-CAPACITY REDUCING VALVE. 2-page Bulletin 56C describes the Atlas No. 1910, Type E, for gas, oil or water service.—Atlas Valve Co., 280 South St., Newark 5, N. J.

For more information circle **254** on inquiry card.

SERVOVALVES. 7-page Catalog 150 describes operating principles, design features and performance characteristics of pressure-control servovalves. —Moog Valve Co. Inc., East Aurora, N. Y.

For more information circle **255** on inquiry card.

ROTARY ACTUATOR. 2-page Product Data Sheet 101-5 describes rotary actuator Type 6116A-1, and contains engineering data and installation sketch.—Lear, Grand Rapids Div., 110 Ionia Avenue, N. W., Grand Rapids 2, Mich.

For more information circle **256** on inquiry card.

SLIDING-GATE CONTROL VALVE. 4-page Bulletin J-170 illustrates and describes sliding-gate diaphragm motor valve, and gives applications.—Jordan Corp., Div. of OPW Corp., 6013 Wiehe Rd., Cincinnati 13, Ohio.

For more information circle **257** on inquiry card.

HYDRAULIC SERVO ACTUATORS. 15-page booklet describes linear and rotary hydraulic servo actuators for ap-

plications requiring wide dynamic speed range and high-frequency response performance.—Dalmo Victor Co., Belmont, Calif.

For more information circle **258** on inquiry card.

TEMPERATURE

PNEUMATIC TEMPERATURE CONTROLS. 4-page folder describes the new line of pneumatic temperature controls introducing the recording Model RVA and the Model IVA.—Partlow Corp., 509 Campion Rd., New Hartford, N. Y.

For more information circle **259** on inquiry card.

TEMPERATURE CONTROLLER. 4-page Bulletin MC-176 contains details on the Series 541 temperature indicating controller.—Fenwal Incorporated, Pleasant St., Ashland, Mass.

For more information circle **260** on inquiry card.

TEMPERATURE CONTROL SYSTEM. 4-page Bulletin 1950 describes Power-O-Matic Control System which automatically proportions minimum wattage in relation to operating temperature and work load.—Blue M Electric Co., 138th & Chatham St., Blue Island, Ill.

For more information circle **261** on inquiry card.

RESISTANCE THERMOMETER WIRE. 10-page brochure on resistance thermometer wire shows graphically resistance versus temperature from 0° to 500°C with various pure metals and alloys used in thermometry.—Secon Metals Corp., 7 Intervale St., White Plains, N. Y.

For more information circle **262** on inquiry card.

ELECTRIC HEATERS. 4-page Bulletin J-1003 describes and illustrates the complete line of Chromalox Flexible and Molded Electric Heaters.—Edwin L. Wiegand Co., 7500 Thomas Blvd., Pittsburgh 8, Pa.

For more information circle **263** on inquiry card.

FLOW, PUMPS

PROPORTIONING PUMP. 2-page Bulletin 1106.20A-1 describes Proportioneers Model 1106 Adjust-O-Feeder for accurate proportioning of general industrial fluids.—B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R. I.

For more information circle **264** on inquiry card.

REFERENCE DRAWINGS for glass, bypass rotameters and extensions, etc. are subject of 2-page sheet.—Brooks Rotameter Co., Lansdale, Penna.

For more information circle **265** on inquiry card.

AIR-FLOW-STUDY INSTRUMENT. 4-page folder describes Visu-Flo, an instrument developed for the study of air or liquid flow problems.—Design Engineers, 214 South Church St., Rockford, Ill.

For more information circle **266** on inquiry card.

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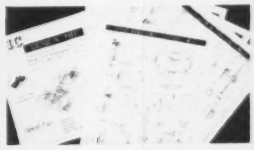

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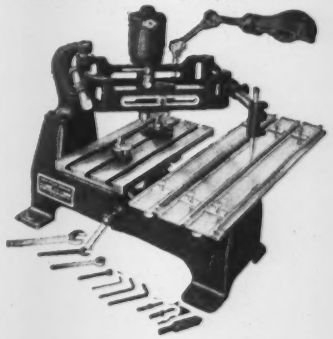

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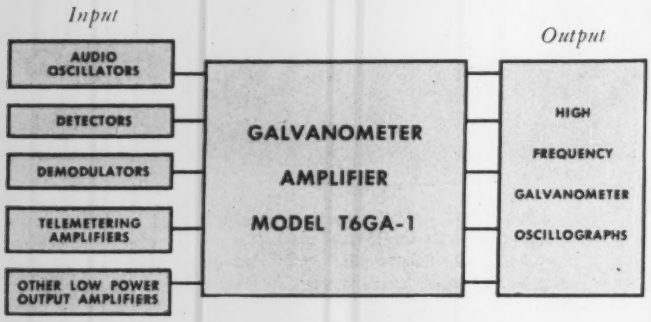
Strengthens Low Power Signals to Drive High Frequency Oscillographs



Galvanometer Amplifier, Model T6GA-1, measures 3½" high, 19" wide, 15½" deep.

DESCRIPTIVE DATA

VOLTAGE GAIN:
Adjustable from 0 to 1.0

OUTPUT (37 OHM LOAD):
±2.4 volts at 65 ma d-c to 8 Kc, limits at ±100 ma.

OUTPUT IMPEDANCE:
2 Ohms d-c to 10 Kc

CONTROLS:
6 GAIN controls, 1 Power ON-OFF switch

INPUT IMPEDANCE: 47 K

ISOLATION:
Individually floating channels for use with ungrounded loads

NOISE:
Less than 3 mv peak-to-peak

DRIFT:
Less than 3 mv/°F

POWER REQUIREMENTS:
115 volts ±10 volts, 50 to 440 cps, 45 watts

With Honeywell's new Galvanometer Amplifier, Model T6GA-1, high frequency oscillographs can now be operated directly by low power input sources of 1 volt or more. These inputs, some of which are shown in the diagram above, should have output impedances of 10 K or less although higher source impedances can be tolerated. Noise and drift are indistinguishable on the recorded output when the galvanometer-amplifier combination has a maximum sensitivity of 1 inch per volt.

The Model T6GA-1 is a compact, six channel, three stage transistor d-c amplifier with overload protection to eliminate both danger of transistor damage and galvanometer burnout.

Each of the six amplifier channels is isolated from ground by individual floating power supplies. Write for Bulletin B-ET6 to Minneapolis-Honeywell, Boston Division, Dept. 50, 40 Life Street, Boston, Mass.

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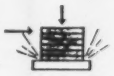
NEW LITERATURE



FORCE, PRESSURE, WEIGHT

FORCE INSTRUMENTATION. data processing and calibration equipment, weighing systems, and special recording instrumentation are described in 2-page Bulletin G-100.—Gilmore Industries, Inc., 13015 Woodland Ave., Cleveland 20, Ohio.

For more information circle **267** on inquiry card.

PRESSURE INSTRUMENTS are described in Spec Sheets 11-1451P-1 to 5. —Fischer & Porter Co., 843 Jacksonville Rd., Hatboro, Penna.

For more information circle **268** on inquiry card.

HYDRAULIC CRANE SCALE. 4-page Bulletin M-25 describes the new SU-5 series hydraulic crane scales.—Martin-Decker Corp., 3431 Cherry Ave., Long Beach 7, Calif.

For more information circle **269** on inquiry card.

SERVOMANOMETERS. 16-page Bulletin 500 describes servomanometer techniques applied to mechanical measurements.—Exactel Instrument Co., 5545 Eva Ave., Los Altos, Calif.

For more information circle **270** on inquiry card.

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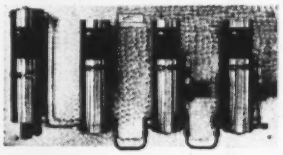

Remove moisture & oil vapor from gases with working pressures up to 12,000 PSI; dew points -100°F.

For more information circle **139** on inquiry card.

PRESSURE GAGES. 2-page catalog illustrates and describes safety gage case for high-pressure gages.—Kunkle Valve Co., 120 South Clinton St., Fort Wayne, Ind.

For more information circle **271** on inquiry card.

ELECTRICAL, ELECTRONIC INSTRUMENTS

AUTOTRANSFORMERS. 2-page spec sheet illustrates, describes and specifies new Type W 20 Variac.—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

For more information circle **272** on inquiry card.

ELECTRIC-QUANTITY MEASUREMENT SYSTEMS. 15-page Bulletin GEA-6788 includes descriptions and specifications for new airborn a-c and d-c panel instruments, aircraft instrument current transformers, and ground maintenance equipment.—General Electric Co., Schenectady 5, N. Y.

For more information circle **273** on inquiry card.

LABORATORY TEST INSTRUMENTS. Catalog 558 describes precision laboratory test instruments, which include low-frequency "Q" indicators, comparison & limit bridges, incremental inductance bridges, universal bridges, megohmmeters, decade industors and decade capacitors, and high-speed electronic counters.—Freed Transformer Co., Inc., 1707 Weirfield St., Brooklyn (Ridgewood) 27, L. I., N. Y.

For more information circle **274** on inquiry card.

PANEL METERS. 8-page Bulletin 3-610 covers the Roller-Smith lines of oil circuit breakers; subway switches; precision balances; rotary switches; and panel, switchboard and portable instruments.—Federal Pacific Electric Co., 50 Paris St., Newark 1, N. J.

For more information circle **275** on inquiry card.

ELECTRONIC VOLTMETER. 2-page Bulletin 7007A describes and specifies sensitive, multi-range a-c electronic voltmeter, Model 15A.—Consolidated Electrodynamics Corp., Alectra Div., 325 North Altadena Drive, Pasadena, Calif.

For more information circle **276** on inquiry card.

METERS. 8-page Bulletin 81100 describes and illustrates ruggedized electrical meters for military and commercial use.—WacLine, 35 South St., Clair St., Dayton 2, Ohio.

For more information circle **277** on inquiry card.

MICRO VOLT-AMMETER. 4-page issue of Keithley Engineering Notes, Vol. 7/No. 1, features the Model 150 micro volt-ammeter for measuring voltages as low as 0.03 microvolt and currents down to two micro-microamps.—Keithley Instruments, Inc., 12415 Euclid Ave., Cleveland 6, Ohio.

For more information circle **278** on inquiry card.

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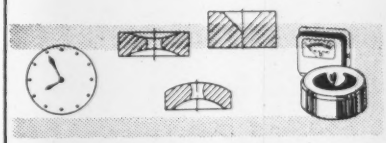

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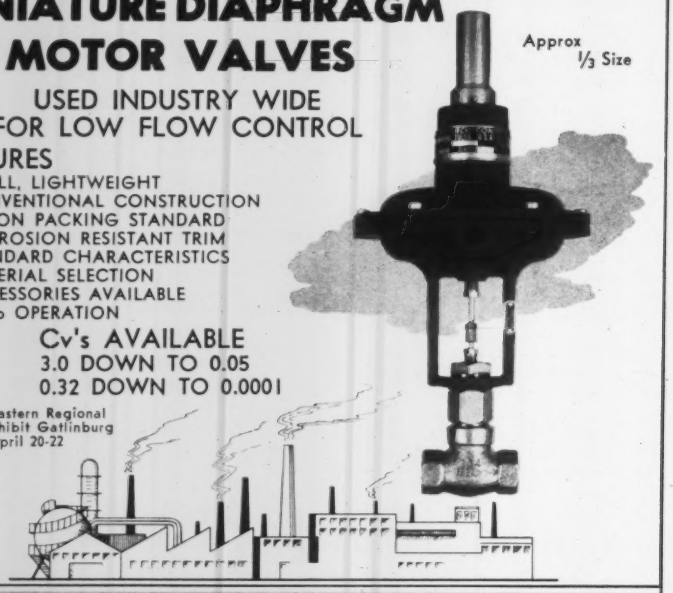

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For more information circle **145** on inquiry card.

NEW LITERATURE

POWER SUPPLIES. 4-page Bulletin PS-2009 describes a series of 26 all-solid-state regulated d-c power supplies for built-in applications.—Deltron Incorporated, 2905 N. Leithgow St., Phila. 33, Pa.
For more information circle **279** on inquiry card.

DATA HANDLING

GAS-FLOW COMPUTING SYSTEMS. Package of 4 Application Engineering Data Bulletins (783-30,-31,-32, and -33) describe single- and multiple-meter-run computers for gas dispatching.—The Foxboro Co., Foxboro, Mass.
For more information circle **280** on inquiry card.

COMPUTER. 6-page Brochure S-526R1 gives specifications and basic features, illustrates major components, and lists applications of general purpose computer.—Royal McBee Corp., Data Processing Div., Port Chester, N. Y.
For more information circle **281** on inquiry card.

DATA REDUCTION SYSTEM. 4-page brochure describes Mark I PDM-to-digital computer format telemetry data system.—Epsco, Inc., 588 Commonwealth Ave., Boston 15, Mass.
For more information circle **282** on inquiry card.

TRANSISTORIZED PLOTTER. 4-page Bulletin PIR824-1 presents preliminary information on wall- or table-top model Variplotter 205S or 205T.—Electronic Associates, Inc., Long Branch, N. J.
For more information circle **283** on inquiry card.

DATA TRANSLATOR. 2-page Bulletin 121 contains description and diagrams of T-121 translator which translates code into decimal contact closures.—Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.
For more information circle **284** on inquiry card.

RECORDERS

MAGNETIC TAPE RECORDER. 8-page bulletin describes and specifies the FL-100 continuous-loop magnetic tape recorder.—Ampex Corp., 934 Charter St., Redwood City, Calif.
For more information circle **285** on inquiry card.

X-Y RECORDER. 4-page bulletin contains description and technical data of the HR-92 X-Y recorder.—Houston Instrument Corp., 1717 Clay Ave., Houston 3, Texas.
For more information circle **286** on inquiry card.

ELECTRICAL, ELECTRONIC COMPONENTS

CERAMIC CAPACITORS. 16-page Form 42-588 lists over 600 ceramic capacitors and affords a cross reference.—Centralab, A Div. of Globe-Union, Inc., 900 East Keefe Ave., Milwaukee 1, Wis.
For more information circle **287** on inquiry card.

LINEAR MAGNETIC AMPLIFIERS. 2-page Bulletin S-921 describes new standard line of low-level linear magnetic amplifiers.—Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y.

For more information circle **288** on inquiry card.

CONNECTORS, CABLES

MINIATURE COAX CABLES. 4-page catalog tabulates complete line of miniature coaxial cables—both military-specification and commercial-specification types.—Rex Corp., Aircraft & Electronics Div., West Acton, Mass.

For more information circle **289** on inquiry card.

TEST POINT CONNECTORS. 6-page technical brochure describes and illustrates new series of single and multi-contact test point connectors to check printed circuitry in various applications.—DeJur-Amsco Corp., Electronic Sales Div., 45-01 Northern Blvd., Long Island City 1, N. Y.

For more information circle **290** on inquiry card.

GEARS

CLUSTER GEARS. 20-page booklet "Universal A to Z Design For Unlimited Package Assemblies" outlines a completely new engineering concept in the design of servo-mechanism gear train packages.—PIC Design Corp., 477 Atlantic Ave., East Rockaway, L. I., N. Y.

For more information circle **291** on inquiry card.

PRECISION GEARS. 100-page booklet contains tabulated information on fine-pitch precision stock gears.—U. S. Gear Corp., 81 Bay State Rd., Wakefield, Mass.

For more information circle **292** on inquiry card.

INSPECTION, TOOLS

ROTARY INSPECTION FIXTURE. 4-page Bulletin 855 provides descriptive information on the Roto-Mike for precise checking of angular relationships in shop procedures and engineering specifications.—Sorensen Center-Mikes, Inc., 264 Kossuth St., Bridgeport 8, Conn.

For more information circle **293** on inquiry card.

LINE CLAMP PLIERS. 2-page leaflet contains illustrations and applications of Model 82 pliers for single or multiple line clamping with wire and tube harness clamps.—TA Mfg. Corp., 4607 Alger St., Los Angeles 39, Calif.

For more information circle **294** on inquiry card.

MISCELLANEOUS

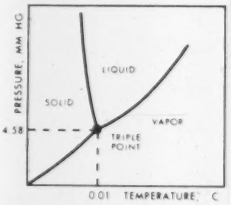
FLEXIBLE SHAFTING. 8-page Bulletin Form 539 describes and lists flexible shafting with various flexible casings.—F. W. Stewart Corp., 4311-13 Ravenswood Ave., Chicago 13, Ill.

For more information circle **295** on inquiry card.

Scientific Announcement

NEW PRIMARY STANDARD FOR TEMPERATURE

A new primary temperature standard, using the triple point of water, is now in use in national standards laboratories throughout the world. This new standard defines the triple point of water as 0.01°C. It has been recommended by the International Committee on Weights and Measures as the standard for the International Temperature Scale, and is already the standard on the thermodynamic scale (273.16K).



Phase Diagram for H_2O

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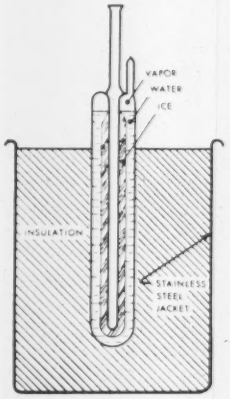

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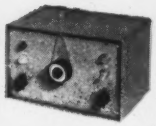

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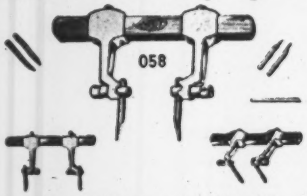

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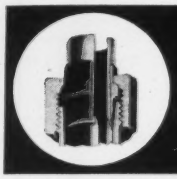

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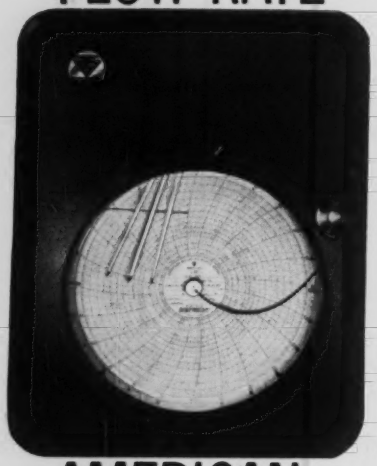

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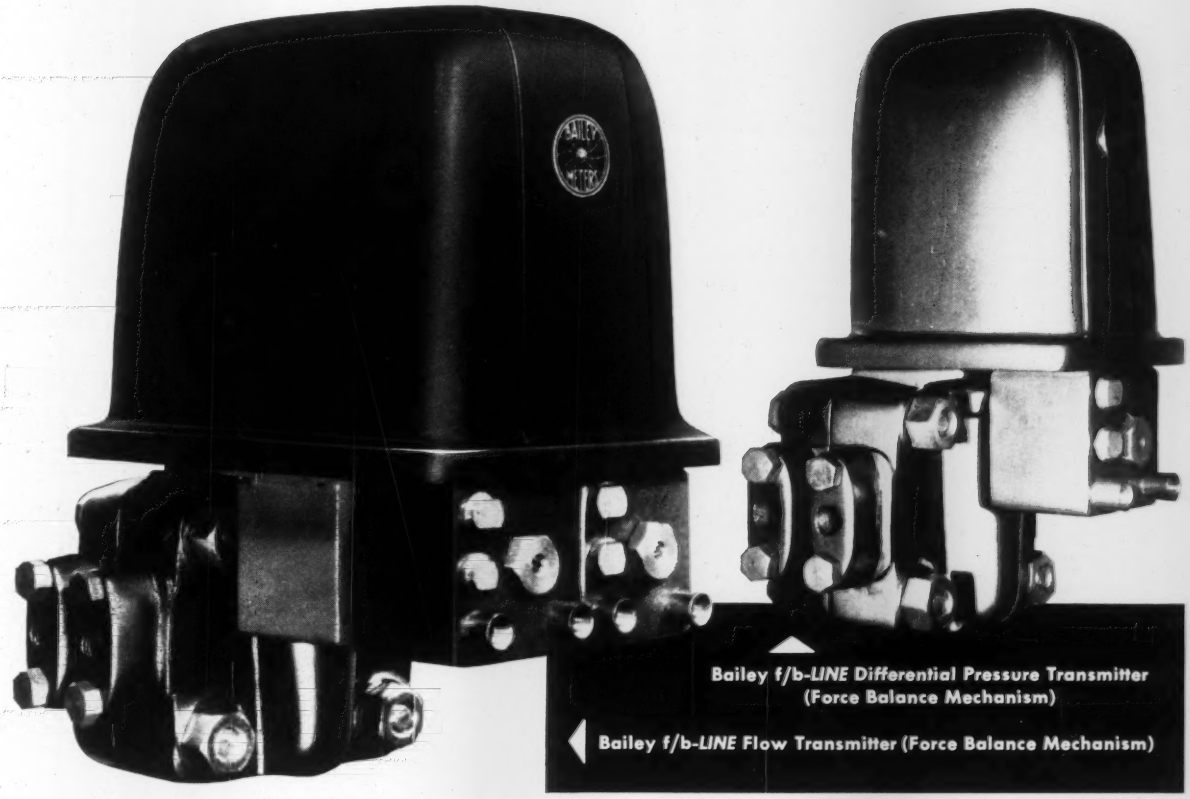

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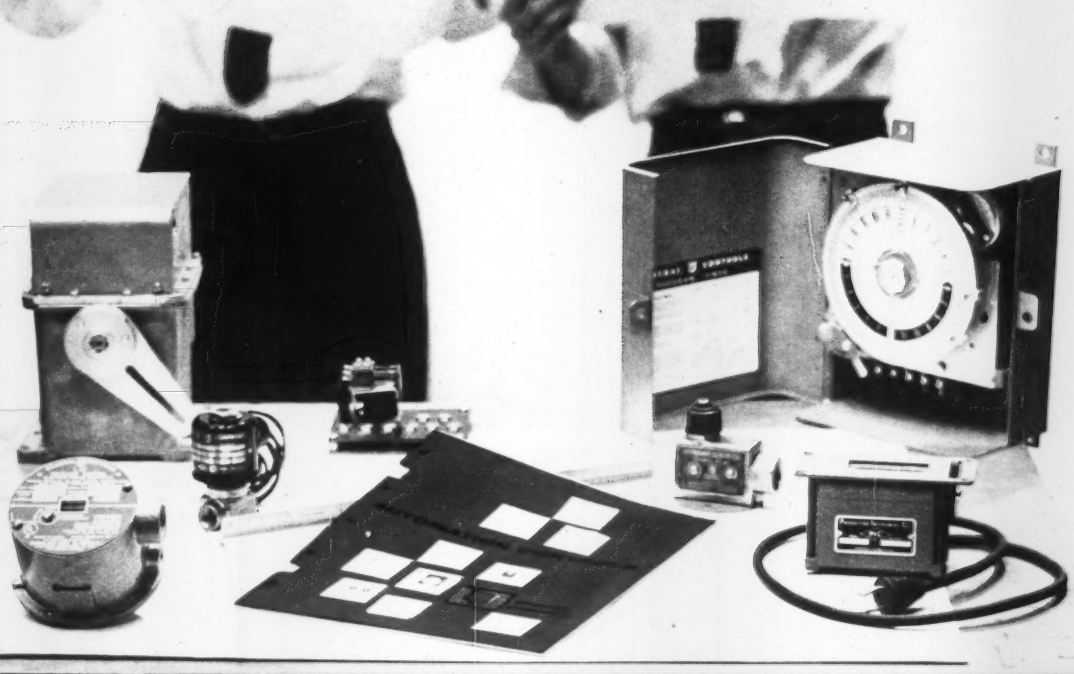

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